PB-230 446

WATER SUPPLY AND WATER QUALITY CONTROL STUDY NEW MELONES PROJECT STANISLAUS RIVER BASIN, CALIFORNIA. A REPORT ON FUTURE WATER QUALITY CONTROL NEEDS AND BENEFITS

Public Health Service
San Francisco, California

January 1965

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WATER SUPPLY AND WATER QUALITY CONTROL STUDY

NEW MELONES PROJECT STANISLAUS RIVER BASIN, CALIFORNIA

A REPORT ON FUTURE WATER QUALITY CONTROL NEEDS AND BENEFITS

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
PUBLIC HEALTH SERVICE, REGION IX
SAN FRANCISCO, CALIFORNIA
JANUARY 1965

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WATER QUALITY CONTROL STUDY

NEW MELONES PROJECT
Stanislaus River Basin, California

Prepared at the Request of

U.S. DEPARTMENT OF THE ARMY - Corps of Engineers, Sacramento District
U.S. DEPARTMENT OF THE INTERIOR - Bureau of Reclamation, Region 2
Sacramento, California

by

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region IX
San Francisco, California

January 1965

Abstract

A study has been made which discloses draft on storage is needed in progressively greater quantities (to the year 2075) in the Stanislaus River Basin, California for the purpose of water quality control. Tangible benefits are estimated to have a present value of $184,000 annually. Significant intangible benefits will also accrue. These conclusions are based on analyses of existing information on water quality, hydrology, economy, and population. Future needs are based on projected population and industrial growth.

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INTRODUCTION

Authority

The Flood Control Act of 1962 authorized the New Melones Dam and Reservoir to be constructed by the Corps of Engineers and to be operated by the Bureau of Reclamation as part of the Central Valley Project. The authorization also contains the following provision: "and provided further, that the Secretary of the Army give consideration during the preconstruction planning for the New Melones project to the advisability of including storage for the regulation of stream flow for the purpose of downstream water quality control."

In a letter dated September 1, 1964, the Bureau of Reclamation requested the Public Health Service to evaluate the need for and value of storage for water quality control in conformance with the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 a(b)).

Purpose and Scope

The purpose of this study is to provide the Corps of Engineers, Sacramento District and the Bureau of Reclamation, Region 2, Sacramento with information about the need for and value of storage in the Stanislaus River Basin for the regulation of stream flow for the purpose of water quality control.

This study is limited to: (1) a determination of the quantity of water needed to control water quality in the Stanislaus River below the proposed New Melones Dam for all beneficial water uses including the fishery and recreational uses, and to improve water quality in the San Joaquin River for irrigation and other purposes; and (2) an evaluation of the water quality and pollution control benefits which will result from the improvement in water quality.

A monetary evaluation was made of those tangible benefits which could be identified and quantified. Other intangible beneficial effects resulting from water quality regulation are described. The time horizon selected for benefit evaluation and projection purposes is the year 2075. Evaluations are made by 25 year intervals beginning with 1975, the estimated initial year of project operation.

This report summarizes the results of engineering and economic analyses of existing information relevant to the proposed project, hydrology of the Stanislaus and San Joaquin Rivers, existing water quality, proposed project operation, water uses, and population and industrial growth. Detailed information and supporting data are presented in the appendix to this report.

Acknowledgments

Valuable assistance and data for this study were provided by personnel of the following agencies:

U. S. Department of the Army, Corps of Engineers
Sacramento District, California

U. S. Department of the Interior, Bureau of Reclamation
Region 2, Sacramento, California

U. S. Department of Interior, Fish and Wildlife Service,
Bureau of Sport Fisheries & Wildlife, Sacramento, California

Central Valley Regional Water Pollution Control Board #5

State of California Department of Water Resources

California State Health Department, Bureau of Sanitary
Engineering

In addition to the above Federal and State agencies, several irrigation districts provided useful information. The Banta - Carbona Irrigation District was particularly helpful. The cooperation, data, and assistance furnished by these agencies is sincerely appreciated.

SUMMARY OF FINDINGS AND CONCLUSIONS

Findings

1. The U.S. Army Corps of Engineers, the construction agency, and the U. S. Bureau of Reclamation, the operating agency, are making a detailed study of an authorized multipurpose water storage project. The project, known as the New Melones Project, is located on the Stanislaus River in Stanislaus County, California, approximately 68 miles above the mouth of the Stanislaus River, a tributary of the San Joaquin River. The project will inundate and replace the existing Melones Dam and reservoir.

2. The Bureau of Reclamation requested the Public Health Service to evaluate the need for and value of including water quality control as a function of the New Melones project.

3. Areas studied by the U. S. Public Health Service include the areas adjacent to Stanislaus River lying below the dam site in Stanislaus and San Joaquin Counties and the area of beneficial uses of San Joaquin River waters below the mouth of the Stanislaus River. See Figure 2 in the Appendix.

4. In 1960, the population of the urbanized areas totaled 12,532. These communities, consisting of Oakdale, Riverbank, Salida, Escalon, and Ripon, are located along the river and serve as local processing and supply centers for the highly developed irrigated agricultural lands adjacent to them. The population of Stanislaus and San Joaquin Counties, in 1960, totaled 407,300.

5. Wastes from the urbanized areas receive primary treatment and discharge to holding ponds. Effluents from the ponds are discharged to the river when holding capacity of the ponds is exceeded and have resulted in damaging pollution of the river for short periods during the canning season.

6. The quality of Stanislaus River water, above the waste discharge points, and the quality of the groundwater is suitable for all beneficial uses in the Stanislaus River Basin.

7. The quality of the water in the San Joaquin River, below the mouth of the Stanislaus River, is generally poor except during flood flows. During summer months, the concentration of total dissolved solids normally ranges upward from 500 mg/l and has exceeded 1200 mg/l.

8. Periodic pollution of the lower Stanislaus River waters and perennial pollution of lower San Joaquin River waters is adversely affecting the use of these waters for municipal, industrial, agriculture, fishing, and recreation purposes.

Conclusions

1. The population of the urbanized areas in the Stanislaus River study area is projected to increase to 53,000 by the year 2000 and to 235,000 by 2075. Population of Stanislaus and San Joaquin Counties is projected to increase to 1,323,000 by 2000 and to 4,739,000 by 2075.

2. The initial mean annual draft on storage in New Melones Reservoir, required to maintain the dissolved oxygen concentration in the Stanislaus River at or above 5 mg/l and to limit the concentration of total dissolved solids in the San Joaquin River at Vernalis to 500 mg/l on a mean monthly basis, during the irrigation season, is 11,100 acre feet. The increasing municipal and industrial waste load (after adequate treatment is provided) will cause the mean annual draft on storage to increase to 15,000 acre feet by the year 2025 and to 36,000 acre feet by 2075. These quantities are in addition to fish releases.

3. With provision of storage for streamflow regulation for water quality control purposes, significant economic and social benefits will accrue to the large and growing population using Stanislaus and San Joaquin River waters for fishing, recreation, agricultural, municipal, and industrial purposes.

4. Water quality control benefits evaluated in monetary terms, which will accrue to the fishery and agricultural interests during the 100 year evaluation period, are estimated to have a total present worth of $5,617,000. The annual equivalent value of these benefits is $184,000.

5. Significant intangible water quality control benefits will also accrue to recreationists using the Stanislaus River and to sport and commercial fishermen, recreationists, industrial and municipal users of the lower San Joaquin River waters.

6. Water quality control releases from New Melones storage project will contribute significantly to the solution of the overall pollution problem in the lower San Joaquin River but should not be considered as a complete solution of this problem.

7. In view of the substantial benefits which will result from storage water releases from New Melones Reservoir, it is recommended that provision for such releases, to the extent feasible and in harmony with other uses of the project, be included in New Melones Project.

8. Benefits resulting from providing storage water for quality control will accrue to hundreds of thousands of people utilizing, for a wide variety of purposes, the waters of the Stanislaus and San Joaquin River. Benefits are, therefore, considered widespread and in harmony with the intent of the Federal Water Pollution Control Act.

9. Municipal and industrial water use, along the Stanislaus River below New Melones, is projected to increase from 3 million gallons per day (3,000 acre feet/year) in 1960 to 72 million gallons per day (81,000 acre feet/year) in 2075. The portion of this additional water need that develops in the Stanislaus River Basin should be supplied by the New Melones Project unless a study indicates that groundwater resources, of satisfactory quality, and/or decreasing agricultural usage will satisfy this anticipated need.

DESCRIPTION OF PROJECT

The New Melones Project (1) consists of a 600 foot high earth and rockfill dam that creates a 2,400,000 acre foot reservoir, and a power plant on the Stanislaus River. Purposes of the project, as authorized, were flood control, water conservation, power, fish and wildlife, and recreation. The damsite is located 3/4 mile below existing Melones Dam and reservoir (capacity of 112,500 acre feet), both of which will be inundated by New Melones Reservoir. Immediately downstream from the New Melones site is the backwater of Tulloch Reservoir used for water conservation, power and recreation. Releases from New Melones will flow through Tulloch Reservoir to Goodwin Dam and reservoir (500 acre foot capacity) for diversion to existing irrigation canals or release to the Stanislaus River. These existing developments as well as two upper basin reservoirs (Donnells and Beardsley) are all owned and operated by the Oakdale and South San Joaquin Irrigation Districts.

Above the New Melones damsite, located 40 miles east of Stockton, the Stanislaus River drains a narrow basin of 900 square miles on the western slope of the Sierra Nevada. Elevation varies from 503 feet at the damsite to 10,000 feet at the crest of the drainage divide. The slopes of the Sierra Nevada are generally covered with trees and the foothill area is covered by grasses, brush, and scattered oaks. Figure 1 shows the location map and the Stanislaus River Basin.

The proposed New Melones Project will alter existing surface water hydrology. The Corps of Engineers proposes to allocate 450,000 acre feet to flood control storage in New Melones between 1 November and 20 March and the amount of storage needed between 20 March and 1 August will be determined from snow surveys. As currently proposed, construction of the dam will eliminate essentially all spills below Goodwin Dam except for flood control releases and the flows requested by the U. S. Fish and Wildlife Service.

DESCRIPTION OF STUDY AREA

The study area includes all of the Stanislaus River Basin and the San Joaquin River below the confluence of the Stanislaus, including the Sacramento - San Joaquin Delta (see Figures 1 and 2 in the Appendix). This area has the typical two-season climate of the Central Valley of California, characterized by frequent rain or snow during the winters and hot, dry weather during the summers.

Below New Melones damsite, the Stanislaus River flows for 11 miles to the foothill line near Knights Ferry. The river then runs for 57 miles along the valley floor to its confluence with the San Joaquin River, 3.0 miles above the Vernalis gaging station. Lands of the valley floor are highly productive, consisting mostly of fine alluvium and have been extensively developed for irrigated agriculture. Along the valley floor, the river generally has one high bank and one lower bank with the flood plain being from 1/2 to 3 miles wide.

The lower reach of the San Joaquin River is a portion of the Sacramento - San Joaquin Delta which is a vast area comprised of over 500,000 acres of irrigated farm land located chiefly on some 50 islands situated at or below sea level and protected by levees. More than 700 miles of interconnected channels conduct flows and serve as reservoirs for agricultural operations. The existing Delta water uses include municipal, industrial, agricultural, fishing, recreational, navigational, salinity repulsion, and waste assimilation.

WATER RESOURCES OF THE STUDY AREA

Surface Water

Surface water resources of the study area are considered in several sections: (1) the Stanislaus River upstream from Goodwin Dam, (2) the Stanislaus River below Goodwin Dam; (3) the San Joaquin River below the confluence of the Stanislaus River; and (4) Sacramento - San Joaquin Delta.

In the Stanislaus River Basin, normal annual precipitation is about 12 inches in the valley and increases to about 55 inches above 7,000 feet elevation. Virtually, all of the precipitation falls in the period from 1 November - 30 April. There is runoff during the rainy season from precipitation and melting snow at the lower elevations. Above the 5,000 foot level, a snow pack usually accumulates through the winter season and melts during April, May, June, and July.

The "impaired" (assume present degree of development existed during the 1903 - 1936 period of record) mean annual runoff at Melones Reservoir is 1,125,000 acre feet. The maximum annual runoff was 2,569,000 acre feet (1907) and the minimum was 246,000 (1924). Sixty-two percent of the mean annual runoff occurs during April, May, and June while less than 2.5 percent occurs during August, September and October (2).

There are 9 major storage reservoirs in the Stanislaus River Basin, six of these reservoirs are upstream from existing Melones Reservoir and have a total storage capacity of 205,600 acre feet (see Table 1). Two of the 6 reservoirs, Beardsley and Donnells, are owned and operated by the Oakdale and South San Joaquin Irrigation Districts (ID) and in conjunction with Tulloch Reservoir (below Melones) comprise the Tri-Dam Project. The remaining 4 reservoirs are owned by Pacific Gas and Electric Company and are operated primarily for hydroelectric power generation.

The South San Joaquin Canal diverts from the north bank of the Stanislaus River at Goodwin Dam to supply the South San Joaquin I.D. and the portion of the Oakdale I.D. lying north of the Stanislaus. Also diverting at Goodwin Dam, from the south bank, is the Oakdale Canal which serves the Oakdale I.D. land lying south of the Stanislaus. The average annual diversion during the 1958 - 1962 period was 362,000 acre feet for the South San Joaquin Canal and 157,000 acre feet in the Oakdale Canal.

TABLE 1

MAJOR RESERVOIRS IN THE STANISLAUS RIVER BASIN

Name	Stream	Storage Capacity (Acre-Feet)	(1) Owner	(2) Use
Spicer Meadows	Highland Creek	4,000	PG&E	P,I
Lyons	South Fork Stanislaus	5,500	PG&E	P,I
Strawberry	South Fork Stanislaus	18,600	PG&E	P
Relief	Relief Creek	15,100	PG&E	P
Donnells (3)	Middle Fork Stanislaus	64,500	ID	P,I
Beardsley (3)	Middle Fork Stanislaus	97,500	ID	P,I
Melones (3)	Stanislaus	112,500	ID	P,I
Tulloch	Stanislaus	68,400	ID	P,I
Goodwin	Stanislaus	500	ID	D
	TOTAL	386,600		
	ROUNDED	387,000		

(1) PG&E is Pacific Gas and Electric Company
ID is Oakdale and South San Joaquin Irrigation Districts

(2) P is power
I is irrigation
D is diversion

(3) Tri-Dam Project

There is not a regular release schedule from Goodwin Dam to the Stanislaus River. However, due to spills (which would have occurred 21 out of 25 years in the 1921-46 period under Tri-Dam conditions) and, at times, water from power releases in excess of irrigation diversions, there is a substantial amount of water passing Goodwin Dam in most years. These spills normally occur during the months of January through June. During periods when Goodwin Dam is not spilling, flows at the U. S. Geological Survey (USGS) gaging station 1.0 mile below Goodwin Dam are usually less than 25 cfs and in the June - September period, are usually less than 5 cfs. During the months of primary concern (June-October) the flow in the Stanislaus increases downstream between Goodwin Dam and Ripon due to agricultural return flows and the high ground water table. Between Ripon and the San Joaquin River, there is normally a decrease in flow due to extensive withdrawals by private irrigators. The range of flows and diversions in these reaches is given in Table 2 and the flows, diversions, and accretions are shown for median month conditions in Figure 3.

It is assumed that the magnitude of accretions and diversions will not change significantly under project conditions since irrigated acreage is expected to increase very little in the service area and since depletion of ground water does not appear likely.

The San Joaquin River above Vernalis drains an area of 14,010 square miles of which almost 70 percent is classified as mountain and foothill terrain. The major rivers tributary to the San Joaquin River are the Merced, Tuolumne, and Stanislaus. All of these tributaries are regulated by existing storage facilities and as a result summer stream flows are dependent primarily upon storage releases and irrigation return flow.

The average annual unimpaired runoff at Vernalis would be about 5,560,000 acre feet. The Bureau of Reclamation estimates the annual diversions are 3,850,000 acre feet, some of which returns to the streams. For the 1921-22 to 1945-46 period, the mean annual historical flow was 3,800,000 acre feet and under project conditions (present development plus proposed development on Tuolumne, Merced, Chowchilla, and Fresno Rivers), it would be 2,380,000 acre feet. The median flow would be 1,889,000 acre feet.

At the present time, outflow from the Stanislaus River comprises about 25% of the mean annual flow at Vernalis (1949-61 period of record) and during the July - October period of low flows it is about 15%.

Hydrology in the Sacramento - San Joaquin Delta is complex. Inflows are from the Sacramento, San Joaquin, Cosumnes, Mokelumne, and Calaveras Rivers. The entire area is subject to tidal influence and

TABLE 2
FLOW AND DIVERSIONS - DRY SEASON
STANISLAUS RIVER BASIN
(Thousand Acre Feet)

Gaging Station	June		July		August		September		October	
	MONTH									
	FLOW									
	1/10 Year 1/	Median Year	1/10 Year	Median Year	1/10 Year	Median Year	1/10 Year	Median Year	1/10 Year	Median Year
Goodwin Dam	0.2	>50	0.1	0.3	0.1	0.2	0.1	0.2	1.4	3.9
Orange Blossom	1.7	>50	1.3	1.8	1.3	1.9	1.3	1.5	2.1	4.6
Riverbank	3.8	>50	3.4	5.8	3.3	4.8	3.3	4.8	4.2	7.8
Ripon	5.2	>50	5.1	12.3	5.9	10.8	5.9	10.8	6.8	13.5
Mouth	1.0	>50	1.5	10.5	1.9	8.4	3.2	10.5	6.8	13.5

DIVERSIONS

Reach	Range	Median	Range	Median	Range	Median	Range	Median	Range	Median
Orange Blossom - Riverbank	0.2-0.5	0.3	0.2-0.5	0.4	0.2-0.5	0.4	0.0-0.2	0.1	0.0-0.1	0
Riverbank-Ripon	0.3-0.9	0.6	0.5-1.2	0.6	0.6-0.9	0.8	0.2-0.6	0.5	0.0-0.3	0.1
Ripon-Mouth	3.9-7.9	5.9	4.8-8.8	6.8	4.4-8.3	6.1	3.3-6.0	4.3	0.9-3.0	2.7

1/ 1/10 year refers to the one in ten year low flow condition for given month.

References: California Department of Water Resources, Bulletins 23-56 to 23-61, Surface Water Flow for 1956-61.

California Department of Water Resources, Sacramento - San Joaquin Water Supervision, 1949-55.

some incursion of saline water from Suisun Bay will occur under low flow conditions. An average of over a million acre feet/year is pumped from the Delta, primarily to the Delta-Mendota Canal. This pumping causes large quantities of Sacramento River water to flow across the Delta and the water exported is a mixture of all inflows. The Delta is extremely important to future development of the California Water Plan and Central Valley Project since water being exported to the southern San Joaquin Valley and Southern California will be pumped from this region. Delta hydrology could be significantly altered if the means of exporting water is changed. The future method of transporting water across the Delta has not been selected but the Peripheral Canal plan (3) appears to be the most likely scheme. This plan proposes to transport Sacramento River water around the Delta and directly to the export pumps near Tracy, thus eliminating any hydraulic connection to the Delta.

At the present time, there are no releases for water quality control purposes from existing reservoirs on the Stanislaus River.

Groundwater

The U. S. Geological Survey has estimated that the Oakdale - Riverbank and the Ripon - Escalon - Salida ground water aquifers have a storage capacity of 363,000 acre feet between depths of 10 and 50 feet and 984,000 acre feet between 50 and 200 feet. (4). Since most of the area currently has a depth to groundwater of less than 40 feet, the existing ground water storage to a depth of 200 feet probably exceeds 1,000,000 acre feet. Due to the availability of surface water from the Stanislaus and Tuolumne Rivers, the ground water table is not being excessively pumped and the level of the water table remained essentially constant during the 1951-61 period. The high ground water table must be controlled by drainage wells in some areas to prevent water logging of lands and this high water table is responsible for part of the accretions observed along the Stanislaus between Goodwin Dam and Ripon.

The safe annual yield of the ground water basin is not available but is approximately equal to the average withdrawal rate plus the outflow to the Stanislaus River. During the 1951-61 period an average of 130,000 acre feet per year was pumped for irrigation use by the 3 irrigation districts while the amount pumped by private irrigators is unknown. All of the cities along the Stanislaus obtain their municipal water from the groundwater and the annual quantity pumped for this purpose is about 3000 acre feet at the present time.

Other Potential Sources of Supply

Any additional supplies after construction of the New Melones Project would have to come from water reuse, increased groundwater yield, or importation.

Quality of Water Available (5)

Quality of Stanislaus River water at Tulloch Reservoir is very high. The chemical quality meets U. S. Public Health Service Drinking Water Standards in all respects and, with adequate treatment, is capable of meeting the physical and bacteriological standards at all times.

The dissolved oxygen (DO) concentration in the Stanislaus River is over 6 mg/l most of the year. However, in recent years, the City of Riverbank has discharged to the river during the canning season, which has caused DO concentrations to drop below 1 mg/l on many occasions. The only reach of stream affected by this discharge is from Riverbank to Ripon.

Since 1958, the first full year under Tri-Dam Project operation, the annual flow-weighted total dissolved solids (TDS concentration of monthly grab samples) has ranged from 33 to 65 mg/l with a median value of 41 mg/l. The low TDS concentration makes this an exceptionally good quality of water for irrigation and most of the water consumptively used will probably be for irrigation. In the 1958-63 period, the annual flow weighted TDS 1.7 miles upstream from the mouth of the Stanislaus varied between 60 and 167 mg/l with a median of 141 mg/l. This increased TDS is undoubtedly due to surface drainage, especially irrigation return flows, and groundwater inflow. TDS concentrations are noticeably higher during low streamflow, the median value being about 185 mg/l during July - October and the maximum observed was 225 mg/l. Continuous conductivity measurements have been taken during 1964 (a drier than normal year) by the Department of Water Resources at a station 9.5 miles above the mouth of the Stanislaus River and the average TDS from May through September was about 200 mg/l with a maximum day of 226 mg/l. These higher concentrations are acceptable for agricultural use but are less effective in diluting the much higher concentrations occurring in the San Joaquin River. The TDS concentration at the mouth of the Stanislaus is expected to remain about the same since future irrigation practices are not expected to change significantly.

Under present conditions, the summer time flows in the San Joaquin at Vernalis are comprised mainly of irrigation return flows and during dry years, there is an increased upstream reuse of water. The TDS concentration is higher in years of low flow (see Figure 4) and during the unusually dry year of 1961, TDS concentrations as high as 1220 mg/l were observed and for a 120 day period (June 10 - October 10) the minimum was 780 mg/l. It is apparent that the diluting effect of the Stanislaus River outflow is important in controlling TDS concentration at Vernalis. During the summer of 1961, this flow (normally about 15%) comprised less than 1% of the Vernalis flow.

There are seasonal water quality problems in the Sacramento - San Joaquin Delta due to both high TDS and low DO concentrations. The inter-relationships affecting Delta water quality are complex, but at the present time, quality is primarily determined by the magnitude and quality of inflows from the San Joaquin and Sacramento Rivers, by irrigation in the Delta, and by the magnitude of pumping from the Delta (near Tracy) which materially influences the degree of mixing of waters from the two rivers.

If the proposed Peripheral Canal Plan is adopted the effect of the San Joaquin River on water quality in Delta channels will be increased.

Groundwater in the area between the Stanislaus and Tuolumne Rivers is of good quality with the following median concentrations: (6) TDS about 200 mg/l; hardness, 100 mg/l; boron, 0.0 mg/l; and nitrate, about 9.0 mg/l. One irrigation well sampled had a nitrate concentration of 40 mg/l which approaches the level that the Public Health Service Drinking Water Standards considers potentially dangerous for infant feeding. More limited data for the area immediately north of the Stanislaus River indicates water of comparable quality. Ground and surface water quality data is presented in Table 3.

TABLE 3

SURFACE AND GROUND WATER QUALITY

IN THE

STANISLAUS RIVER BASIN
(milligrams per liter)

Chemical Constituent	Stanislaus River (1) at Tulloch Reservoir	Near(1) Mouth	Municipal Groundwater Supplies(2)
TDS	25-175 (3)	32-226	86-288
Total Hardness	0-19	21-197	49-151
Alkalinity	-	-	46-152
Chloride	0-7	0-24	5-29
Sulfate	0-7	0-11	<1-22
Nitrate - Nitrogen	0-0.3	0-0.6	<1-6
Fluoride	0-0.2	0-0.3	<0.1-0.2
Calcium	4.9-25	5.5-31	11-33
Magnesium	0.5-9.5	1.2-14	5-17
Sodium	1.3-15	1.5-22	17-25
Iron	-		<0.1

(1) Period of record, July 1956 to December 1961 at Tulloch and April 1951 - December 1961 near mouth. Source is California Department of Water Resources Bulletin No. 65-61.

(2) Supplies of Oakdale, Escalon, Riverbank, Ripon, Salida. Source is California Domestic Water Supplies, State of California, Department of Public Health, 1962.

(3) Median annual flow weighted concentration from 1958-63 was 41 mg/l.

General

Economic and demographic studies of the Stanislaus River Study Area and of the lower San Joaquin River Basin are intended for use particularly in assisting in the overall problem of assessing future water quality control requirements in the Stanislaus River. And they are also used in assessing the effects of improvement in the quality of the water in the San Joaquin River below the mouth of the Stanislaus River, which could be met by storage in New Melones Reservoir.

The principal factors determining future water needs and pollution problems in the Stanislaus River Study Area are the population and industrial developments. As these increase, municipal and industrial use of water and waste loads will also increase.

The urbanized areas in the Stanislaus River Study Area, which in the future are expected to have centralized sewage collection, treatment, and disposal systems, consist of the communities of Oakdale, Escalon, Riverbank, Salida, and Ripon, located in San Joaquin and Stanislaus Counties. These communities are situated on the highly fertile San Joaquin Valley floor and are relatively close together. Oakdale, Riverbank, and Escalon are within 6 miles of each other. Salida and Ripon are located across the river from each other, a distance of 3 miles. Portions of these areas are not in the Stanislaus River drainage but they do dispose of their wastes to the basin. Economically and culturally, these communities are tied to Stockton 15 to 30 miles to the northwest and Modesto 5 to 20 miles to the south. Their principal functions are the processing, warehousing, and distribution of highly diversified agricultural commodities produced near-by, providing agriculturally oriented services, and as residential areas for people employed in Stockton and Modesto.

The analysis of present and projected future population and economic conditions in the Stanislaus River Study Area has been restricted to a review of available information developed by the California Department of Water Resources, U. S. Department of Commerce, Bureau of Census, and other agencies. In general, these projections have been developed on State, Regional, and County bases, and are dependent upon future stable international conditions, an expanding state and national economy in which increasing amounts of goods and services are likely to be required to meet the needs of a growing population, higher levels of living, and international commitments.

Specific historical information on the economic development and population growth of the urbanized areas in the Stanislaus River Study Area

are inadequate as a basis for projections. The communities are relatively small. They are, however, strategically located with respect to agricultural production, transportation facilities, and nearness to Stockton and Modesto. Population growth and economic development of the urbanized areas are, therefore, expected to share in and contribute proportionally to the projected growth of the larger area of which they are a part.

Economic opportunities for industrial development in the Stockton-Modesto area and in the Stanislaus River Study Area are excellent. The area has a large pool of labor, personal income and level of living is high, and the area is strategically located with respect to transportation networks and large existing and giant potential markets for agricultural and industrial goods. The presence of extensive areas of suitable land, adequate supplies of high quality water, desirable climatic conditions, and proximity to various extensive outdoor recreation opportunities are also favorable to continued growth of existing industry and attraction of new industry to the area.

To insure as much accuracy in the projections of the population and industrial activity of the urbanized areas in the Stanislaus River Study Area as possible, the ratio method of forecasting was adopted for this study. This method involves analyzing and projecting the historical ratio of population growth and economic activity of Stanislaus and San Joaquin Counties with the projected pattern of the Region and State. By extrapolating past trends changing ratios, when present, are reflected in the projections. Since available projections do not go beyond the year 2020, estimates for the year 2075 were obtained by extension of trends. In general, aggregative totals for the two counties involved were projected first and then the ratios between the county and the urbanized areas were used in developing estimates of the future population and pattern of economic activity within the urbanized areas. For greater detail of methodology and statistical data, the reader is referred to Appendix A of the report, "San Joaquin Valley and Sacramento-San Joaquin Delta California," by Department of Health, Education, and Welfare, Public Health Service, Region IX, San Francisco, California. (7).

Population

The population of the urbanized areas in the Stanislaus River Study Area below the proposed New Melones Dam in 1960 totaled 12,532 (see Table 4). The total population of these urbanized areas is projected to increase to 53,000 by the year 2000. This rate of growth results in roughly doubling of the population every 20 years and corresponds to the historical rate of growth of the State of California. The population of the urbanized areas is projected to increase to 235,000 by the

TABLE 4

POPULATION OF URBANIZED AREAS 1950 AND 1960
STANISLAUS RIVER STUDY AREA, CALIFORNIA

URBANIZED AREA	1950	1960	PERCENTAGE INCREASE
Escalon	-	1,763	-
Oakdale	4,064	4,980	22.5
Riverbank	2,662	2,786	4.7
Ripon	1,550	1,894	22.2
Salida	1,300	1,109	-14.7
TOTAL	9,576	12,532	

year 2075 and reflects the declining rate of growth projected for the State after the year 2000. Historical and projected populations and decennial rates of growth for the San Joaquin Valley, Stanislaus and San Joaquin Counties and the two clusters of urbanized areas are shown in Table 5.

Employment

In developing the urbanized area forecast of employment, within the framework of the population projections, special attention was given to the probable pattern of economic activity which will be essential to the expanding population and the county regional relationships which have functioned historically. The areas' historical economic activity has been based on the exploitation of natural resources, primarily the production, processing, warehousing, and distribution of agricultural commodities. While it is anticipated that the agricultural sector of the areas' economy will continue to grow, the primary emphasis to future population growth will be dependent upon industrial development. The future pattern of industrial development which will occur in the individual urbanized areas in the Stanislaus River Study Area, is impossible to predict with a reasonable degree of reliability. The areas are so small that the location of an individual plant of significant size in or near any one of the areas would have an immediate and profound effect on its growth. Since it is impossible to predict the location of future industrial plants, the alternative is to project the probable pattern of industrial development for a larger area, in this case, the counties, and assign a proportional share of the employment by industrial category to the two clusters of urbanized areas. This methodology was used in estimating the probable pattern of future employment in the urbanized areas, Table 6.

The projected populations and number of employees by major categories developed in this section provide the basis for estimating future municipal water use, waste loads, and water quality control requirements for the Stanislaus River. These are developed in subsequent sections of this report.

TABLE 5

HISTORICAL AND PROJECTED POPULATIONS

STANISLAUS RIVER STUDY AREA, CALIFORNIA

Year	8 San Joaquin Valley Counties 1/		Stanislaus County		San Joaquin County		Stanislaus River Basin Urbanized Areas			
							Oakdale-Escalon-Riverbank		Salida-Ripon	
	Pop. 1000's	Growth Rate % 2/	Pop. 1000's	Growth Rate %	Pop. 1000's	Growth Rate %	Pop. 1000's	Growth Rate %	Pop. 1000's	Growth Rate %
1900	172.7	5.0	9.5	9.0	35.5	3.6				
1910	291.9	4.7	22.5	6.8	50.7	4.7				
1920	461.1	2.7	43.6	2.6	79.9	2.6				
1930	602.7	2.5	56.6	2.8	102.9	2.7				
1940	770.7	4.4	74.9	5.4	134.2	4.1				
1950	1184.5	3.2	127.2	2.1	200.8	2.2				
1960	1625.3	2.9	157.3	2.4	250.0	2.5	9.5	3.2	3.0	2.9
1970	2170	3.3	200	3.2	321	3.1	13	3.9	4	4.1
1980	2988	4.0	275	3.9	436	3.9	19	4.7	6	5.2
1990	4428	2.6	403	2.4	638	2.4	30	2.9	10	2.7
2000	5706	2.4	513	2.4	810	2.3	40	2.7	13	2.7
2010	7235	2.2	615	2.2	1013	2.2	52	2.6	17	2.1
2020	9000		810	2.0	1260	2.0	67	2.3	21	2.5
2030			987	1.8	1536	1.8	84	2.2	27	2.0
2040			1180	1.6	1836	1.6	104	1.9	33	1.9
2050			1383	1.4	2152	1.4	125	1.7	40	1.6
2060			1589	1.1	2473	1.1	148	1.4	47	1.3
2070			1773	.9	2759	.9	170	1.1	53	1.0
2075			1854		2885		179		56	

1/ California Department of Water Resources

2/ Average annual rate during the decade

TABLE 6

PROJECTED EMPLOYMENT, URBANIZED AREAS
STANISLAUS RIVER STUDY AREA, CALIFORNIA

	1975	2000	2025	2050	2075
	-------Number of employees in thousands-----				
Oakdale - Escalon - Riverbank Area					
Manufacturing					
Furniture-Lumber-Wood	-	.1	.3	.6	.8
Food and Kindred	.8	1.1	1.3	1.6	1.8
Chemical and Allied	.1	.3	.7	1.6	2.0
Other Nondurable	.1	.3	.9	1.8	2.3
Other Manufacturing	.9	2.7	6.2	6.9	11.0
Services	4.7	10.7	18.5	31.2	44.7
Total	6.6	15.2	27.9	43.7	62.6
Salida - Ripon Area					
Manufacturing					
Furniture-Lumber-Wood	-	.1	.2	.2	.3
Food and Kindred	.3	.4	.4	.5	.6
Chemical and Allied	-	-	.1	.2	.2
Other Nondurable	.1	.1	.2	.3	.4
Other Manufacturing	.2	.8	1.8	2.8	4.0
Services	1.5	3.4	6.1	9.8	13.7
Total	2.1	4.8	8.8	13.8	19.2

WATER REQUIREMENTS - MUNICIPAL, INDUSTRIAL, & AGRICULTURAL

Present Water Use

The communities along the Stanislaus River each have their own municipal water supply system. All of these systems are supplied by wells and some provide chlorination for disinfection. The approximate water use of these systems in 1963 was 240 gallons per capita per day (gpcd), which included commercial and some industrial use. Some of the industrial users supply their own water, also from wells. Farms and ranches have their own individual domestic supplies, most probably being from wells.

Agricultural water usage in the Stanislaus area is extensive. Averages of the quantities of ground and surface water delivered by the 3 irrigation districts (not all of the acreage in these districts are in the Stanislaus area) for the period 1951-61 are shown in Table 7. In addition, private irrigators divert about 40,000 acre feet per year from the Stanislaus River but the amount pumped from the groundwater is not known. The quantity of water diverted by the irrigation districts is about 300 times the quantity used for municipal and industrial purposes.

TABLE 7
AVERAGE QUANTITY OF WATER DIVERTED
1961 Period
(Thousand Acre Feet/Year)

Irrigation District	Surface Water (1)	Groundwater	Total
South San Joaquin	250	20	270
Oakdale	277	23	300
Modesto	270	87	357

(1) South San Joaquin and Oakdale I.D. surface water is from the Stanislaus River and Modesto I.D. surface water is from the Tuolumne River.

The groundwater basin is extensively, but not over developed since depth to groundwater is not declining. It is probable that the safe annual yield is greater than existing groundwater withdrawals. However, the extent that the net yield can be increased by careful groundwater management is not known. Undoubtedly, the extensive application of irrigation water in this area contributes to groundwater recharge.

An average of over 560,000 acre feet per year has been diverted from the Stanislaus River. This is about the maximum yield obtainable under present development. The New Melones project will supply an additional annual yield at the dam of about 285,000 acre feet. Although a specific service area has not been established, local agencies are being given an opportunity to contract for this water. Water unused in the local area may be transported from the Stanislaus Basin via the Bureau of Reclamation's proposed East Side Canal.

Future Water Use

The New Melones project is intended to supply existing and future needs of the Stanislaus River Basin prior to diverting water out of the basin. Section 3 of the authorizing act PL 87-874 (76 Stat. 1191) states:

> Sec. 3 Before initiating any diversions of water from the Stanislaus River Basin in connection with operation of the Central Valley Project, the Secretary of the Interior shall determine the quantity of water required to satisfy all existing and anticipated future needs within that basin and the diversions shall at all times be subordinate to the quantities so determined.

It is recognized that not all of the study area is within the drainage boundaries defined by the U.S. Geological Survey and that this provision may not apply to a portion of the future M&I needs projected below.

The Corps of Engineers recognizes that upstream "counties of origin" have first priority on use of Stanislaus River Basin water and that increased consumptive use of water will occur, to the detriment of the New Melones Project. The upstream consumptive use of water needed 50 years after the project is built, is estimated by the Corps of Engineers, the State Department of Water Resources, and the Bureau of Reclamation as about 60,000 acre feet/year.

No other agencies have reported predictions of M&I needs along the lower Stanislaus River or a plan for supplying this future need. The projections and a discussion of the means of satisfying the future demand are discussed below.

Serious consideration should be given to the possibility of supplying the future M&I demand from New Melones. The projected M&I water use is shown in Table 8 and details of the method of calculating this use are included in Appendix A. The increased demand will be considerable, rising from 3 million gallons per day (mgd) in 1960 to 17 mgd in 2000 and 72 mgd in 2075. It is evident that substantial quantities

TABLE 8

PROJECTED MUNICIPAL AND INDUSTRIAL
WATER USE
IN STANISLAUS RIVER SERVICE AREA
BELOW NEW MELONES DAMSITE

Year	Oakdale - Escalon - Riverbank Area		Salida - Ripon Area		Total	
	Municipal (mgd)	Industrial (mgd)	Municipal (mgd)	Industrial (mgd)	(mgd)	(Acre Feet/Yr.)
1975	4.0	1.5	1.2	0.4	7	8,000
2000	10.0	2.8	3.2	0.6	17	19,000
2025	18.9	5.1	6.0	1.2	31	35,000
2050	31.3	8.9	10.0	1.8	52	58,000
2075	44.8	11.3	14.0	2.1	72	81,000

of water will have to be developed unless a sufficient quantity of the water presently used for agriculture can be shifted to M&I use.

It is possible that enough water will be available if a sufficient supply is provided to allow maximum agricultural development in the basin because as the population increases, the acres of irrigated land will decrease due to urbanization. Since quantity of water used per residential acre is approximately the same as that applied to an agricultural acre, the water released from agricultural usage may meet the increasing M&I demand.

Other possible sources of water could result from careful management of the groundwater basins or from use of treated M&I waste effluent for irrigation. The amount of present agricultural water usage is large compared to projected M&I water needs (even in 2075) and even minor changes in irrigation efficiency or cropping practices could drastically increase or decrease the amount of water available for M&I use. Without more knowledge of future irrigation needs or the groundwater yield obtainable it should not be assumed that a plentiful supply of M&I water will always be available.

Another important consideration is water quality. With adequate treatment, both groundwater and Stanislaus River water would be acceptable unless the mineral concentrations, nitrates and/or organic chemicals, such as pesticides, increase significantly in the groundwater. Treatment costs may be lower for groundwater because the surface water should receive filtration and disinfection while disinfection alone may be adequate for the groundwater. Distribution costs would probably be similar since the surface water could be conveyed in existing canals or pumped from the river. Advantages favoring surface water use are: (1) pumping costs would be less for water conveyed in canals; (2) the lower TDS and hardness concentrations in surface water would result in an economic benefit; and (3) future water quality is less likely to change.

It is estimated that in 1975, the mean annual diversion from the San Joaquin River below Vernalis for irrigation use will be about 900,000 acre feet. This water is the only available supply for many irrigators along the San Joaquin River and is the primary source for most. San Joaquin River water is extensively used for irrigation in the Delta and it is estimated that under 1975 conditions, 75% of the water diverted from the San Joaquin River will be consumptively used by agriculture.

WATER QUALITY CONTROL

This section considers the need for storage for water quality control in the New Melones Project: (1) to improve the quality of irrigation water by reducing the total dissolved solids (TDS) concentrations in the lower San Joaquin River and Delta area; and (2) to protect the resident and migratory fishery in the Stanislaus River by maintaining a satisfactory dissolved oxygen concentration.

It is recognized that pollution problems exist in the Sacramento-San Joaquin Delta which could be, at least partially, controlled by releases from the New Melones Project. An evaluation has been made of the beneficial effects the recommended releases from storage will have on TDS concentration in the Delta. However, the problems of dissolved oxygen control in this tidally affected area are complex and will require a more thorough and comprehensive investigation than was possible in this study. The alternatives available for control will not be exhausted with construction of the New Melones Project. Many water resource development projects are being planned by local, state, and federal agencies which could contribute to the control of the overall pollution problem in the San Joaquin River and Delta regions.

Municipal, Industrial, and Agricultural Pollution

As discussed in the Water Resources Section, summertime water in the San Joaquin River is mostly irrigation return flows and is highly mineralized, even during wet years. The dry season outflow from the Stanislaus River (mostly from accretions and return flows) is of much better quality and provides dilution of the poorer quality San Joaquin water.

All towns along the Stanislaus River provide primary treatment (usually Imhoff tanks) with discharge to percolation or oxidation ponds. Riverbank has been discharging from its ponds into the river essentially every year during the canning season (August - October) but the plant is increasing its ponding capacity (with part of the construction costs being paid by a U.S. Public Health Service grant) and will stop or greatly reduce discharges to the river in the immediate future. All other communities have sufficient ponding or percolation capacity to avoid discharging during most years. Most industrial wastes are discharged to the municipal treatment plants but some provide their own treatment or holding ponds.

During recent years, the Riverbank discharge has caused DO concentrations to drop from a 6 to 8 mg/l range above the discharge point to a 0.4-3.4 mg/l range downstream. Typically, the lowest DO concentration is observed at McHenry Avenue Bridge about 3.5 miles below the discharge point (4-6 hours at normal river flow) and reaeration and accretions often

raise the DO to a normal concentration near Ripon (about 20 hours flow from Riverbank). Significant quantities of slime and fungus growths have been observed between Riverbank and McHenry Bridge (8).

The salmon run on the Stanislaus usually begins in October and, in recent years, additional water occasionally has been released at Goodwin Dam to provide a sufficient quantity and quality of water for salmon migration and spawning.

The present waste treatment plant at Riverbank is estimated to remove only 20-30% of the Biochemical Oxygen Demand (BOD) during the canning season, and, therefore, the low DO concentrations in the river are not an indication that the dilution capacity of the river would be insufficient to handle the present waste load if "adequate" (85-90%) treatment is provided. However, the expected population and industrial growth will produce enough wastes in the future to overtax the stream, even after adequate treatment is provided.

Water Quality Objectives

The agricultural water users along the San Joaquin River and in the Delta, need a water quality of sufficiently low TDS to allow continuation of present cropping patterns without increasing operating costs or decreasing yields. Setting a rigid limit on TDS concentration is difficult since any increase in TDS concentration above the damage threshold level results in an economic detriment. A specific damage threshold level is difficult to establish and is dependent upon the interrelationships of the salts, their reaction in the soil, irrigation practices, and crops produced. Some agriculturalists have mentioned a mean concentration of about 300 mg/l as the possible threshold damage level in this area. However, establishment of a quality control objective should realistically consider existing water quality and the contribution to its improvement which can reasonably be expected from the New Melones Project. Various irrigation officials and agricultural specialists familiar with the area believe that a maximum monthly concentration of 500 mg/l, during the irrigation season, would be a reasonable water quality control objective for this study. Under this criterion, the long-time average TDS concentration will be below 500 mg/l at Vernalis. Many irrigators also feel that it is necessary to have a relatively high quality of water during the spring months in order to obtain satisfactory seed germination and establishment of young plants. This study used the 500 mg/l mean monthly concentration limit and determined the need for additional releases from New Melones to meet this criterion.

Dissolved oxygen is the critical water quality parameter on the Stanislaus River. The TDS and specific mineral concentration are

satisfactory for agricultural use along the Stanislaus and withdrawal for domestic purposes is not planned. Bacteriological control will be necessary since there is extensive recreational use, including swimming, especially in the lower reaches. This should be controlled by adequate disinfection at the treatment plant.

The California State Department of Fish and Game considers a minimum DO concentration of 5 mg/l is necessary to maintain a stream fishery and the Central Valley Regional Water Pollution Control Board uses 5 mg/l as a minimum allowable DO in a stream. The Public Health Service agrees that this should be the minimum DO level in a warm water fishing stream. Spawning areas require somewhat higher DO concentrations, but there is no significant spawning below Oakdale and none at all below Riverbank. The fishery that would be protected by maintaining 5 mg/l DO would be the warm water fishery that exists below Riverbank and the migratory salmon and steelhead fishery which moves upstream to spawn.

Flow Regulation

The procedure used to determine need for water quality control flow is explained in more detail in Appendix A. A great many assumptions must be made when predicting future events and the accuracy of the assumptions determine the accuracy of the projection. It is important that assumptions be plainly spelled out so that the projection can easily be changed if any of the variables are later found to differ from the assumptions. The basic assumptions are listed below.

To determine flow regulation required to control the concentration of total dissolved solids, the hydrologic data developed by the Bureau of Reclamation for the historical period of 1921-46, adjusted to project conditions were used. These data indicate the magnitude of the adjusted historical flows at Vernalis, on a month-by-month basis, and use a flow versus TDS curve (derived from historical data at Vernalis) to estimate the TDS concentration that will occur at Vernalis. To determine flow regulation required to control the concentration of dissolved oxygen, domestic and industrial population projections were made for 25 year periods from 1975-2075 and waste loads were determined on a per capita basis. The assumptions used in making these determinations are explained in detail in Appendix A.

Draft on Storage

Flow regulation was determined on a monthly basis for the historical period (1921-46) adjusted to project conditions. The annual draft on storage for each year for both TDS and DO control was compiled and is shown in Table A-4. Fish releases (as shown in Table 9) are assumed to be in the stream prior to water quality control releases. Historical spills in excess of fish releases are used to satisfy as much of the water quality demand as possible and even though the spills will have to be physically released from New Melones, they should not be charged to draft on storage for water quality control since they represent water that would be available without the project. The mean weighted TDS concentration after fish releases was slightly higher than under pre-project conditions so the small increment of releases needed to bring this concentration down to pre-New Melones conditions were considered separately.

Table 10 shows both the draft on storage for water quality control and the total releases needed in addition to fish releases, to provide the necessary river flow. The range of releases is indicated because it is of value in operation studies. It should be noted that only that amount necessary to meet water quality control criteria should be released in any given year. Figure 5 shows the annual flow and mean weighted TDS concentrations at Vernalis for the 1921-46 hydrologic study period, with and without the New Melones project.

The TDS releases are projected to be sufficient to maintain a mean monthly TDS concentration below 500 mg/l at Vernalis at all times during the irrigation season. As noted, the quantity of water needed for TDS control will not change with time because it is assumed that project conditions of flow and TDS at Vernalis will remain constant. The releases necessary for DO control do increase with time and have a benefit for TDS control.

The DO releases are projected to maintain a minimum DO concentration of 5 mg/l in 10 out of 11 years until the year 2075 and they would maintain over 4.5 mg/l even for the 1 in 100 year low flow.

TABLE 9

PROPOSED RELEASES FOR
FISH MITIGATION AND ENHANCEMENT
(Measured below Goodwin Dam)

NEW MELONES PROJECT

Period	Flows Normal Year	(1) Dry Year
October 1 - December 31	200 cfs	150 cfs
January 1 - May 31	125 cfs	100 cfs
June 1 - September 30	100 cfs	50 cfs
Annual Release	98,000 Acre feet	69,000 Acre feet

(1) A dry year is defined as one in which the natural inflow into Shasta, Trinity, Folsom, and Friant Reservoirs, as predicted for the water year, totals less than 5,000,000 acre feet, or one in which the combined water storage in Shasta, Trinity, Whiskeytown, Folsom, Auburn, and New Melones Reservoir, as predicted for the water year is less than 5,000,000 acre feet.

TABLE 10

ANNUAL DRAFT ON STORAGE FOR
WATER QUALITY CONTROL (1)
(Thousand Acre Feet)

	YEAR									
	1975		2000		2025		2050		2075	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
TDS Draft (2) on Storage	10.9	0-48.5	10.9	0-48.5	10.9	0-48.5	10.9	0-48.5	10.9	0-48.5
DO Draft (3) on Storage	0.24	0-2.0	0.44	0-4.0	4.1	0-11.5	13.3	1.5-26.5	25.1	8.5-33.5
Total Draft on Storage	11.1	0-48.5	11.3	0-48.5	15.0	4.0-48.5	24.2	16.5-50.0	36.0	29.5-58.5
Total Release (4) From Storage	15.5	0-66.0	15.7	0-66.0	19.4	4.0-66.0	29.0	16.5-67.5	41.2	29.5-76.5

(1) All releases for water quality control are in addition to the releases requested by the U. S. Fish and Wildlife Service.

(2) TDS releases may be needed in any irrigation month (February through November) but are largest and occur most frequently in April through September.

(3) Months when DO releases are needed: 1975 and 2000 - August; 2025 and 2050 - July through September; 2075 - June through September. (These releases are in addition to releases for TDS control).

(4) Includes all Tri-Dam spills in excess of fish releases that can be used for water quality control. It also includes a portion from storage needed to bring mean weighted TDS concentration up to "without" project conditions.

WATER QUALITY CONTROL BENEFITS

Water quality control benefits are defined as the net contribution to public health, safety, economy, and effectiveness in use and enjoyment of water for all purposes which are subject to detriment or betterment by virtue of a change in water quality.

The protection of public health through the provision of safe and potable water supplies has long been a matter of primary concern to the public health profession. However, the problem of providing adequate quantities of water of suitable quality for all beneficial uses has become increasingly difficult due to the pyramiding water demands and increasing waste loads generated by the rapidly expanding economy. Furthermore, the resulting increase in wastes and land drainage flows in combination with increasing upstream depletion of the Stanislaus River and other tributary streams has caused a gradual degradation in the quality of the San Joaquin River waters and is decreasing their value for many beneficial uses.

The poor water quality conditions which have prevailed in the lower San Joaquin River in the Delta have resulted in water quality problems to municipal, industrial, agricultural, fishing, and recreational users. Industries have suffered considerable expense for water treatment equipment and chemicals, production has been slowed and, in some cases, plants have been forced to shut down for short periods. Penalty costs incurred by industrial water users in the Contra Costa Canal Service Area in 1961 due to total dissolved solids greater than 400 milligrams per liter ranged from $1000 to $158,700 per year and totaled $354,250 (9). Salt water incursion was a contributing factor.

The quality of municipal water diverted from the lower San Joaquin River in the western Delta has fallen below U. S. Public Health Service Standards and have resulted in complaints on taste, odor, and color as well as complaints regarding hardness as it effects the use of soaps and detergents.

Agriculturalists have suffered excessive leaching and drainage costs, lower income from reduced crop yields, seed germination failure, restriction to salt tolerant crops, and physical damage to orchards, crops, and land due to excessive salinity. Warren R. Schoonover estimates that due to increasing salinity in irrigation water supplies diverted from the San Joaquin River excess costs incurred by West Stanislaus, Banta-Carbona, and Patterson Irrigation Districts, totaled $809,900 through 1961 (10).

In 1961, Banta-Carbona Irrigation District installed an auxillary diversion and pipeline facility to obtain water from the Delta-Mendota Canal for the purpose of diluting salinity polluted waters diverted from the San Joaquin River. The cost of this facility was

$52,000 and is now used to augment the irrigation water supply as well as for salinity control. In 1964, the District purchased 10,000 acre feet of water from the Bureau of Reclamation at a total cost of $35,000, an excess cost of $20,000, solely for the purpose of mixing with salinity polluted San Joaquin water to prevent severe salinity damages to agriculture. Orchards have been severely damaged with kills ranging up to 50 percent of the trees. The necessity of applying excessive amounts of water to lands to leach the salts from the soil is contributing to the drainage problem and is resulting in water logging of District lands. The Irrigation District is now in the process of organizing a drainage district covering about 8,000 acres. The cost of installing drainage facilities is expected to range from $100 to $200 per acre. Banta-Carbona Irrigation District only serves 15,000 acres of land but is considered illustrative of the salinity problem on lands irrigated with waters diverted from the lower San Joaquin River.

The fishery resource of the Stanislaus and San Joaquin Rivers has suffered from depletion of stream flow, flow reversals, and from pollution by organic wastes and chemicals of known toxicity. This problem is especially acute in the vicinity of Stockton. The anadromous fish runs in the San Joaquin River system have been severely depleted. During recent years, only remnants of the former abundant runs have been reported by the U. S. Fish and Wildlife Service. Numerous fish kills have occurred as a result of seasonal organic waste discharges. Skinner (11) reported the annual value of the commercial fishery resource in the San Francisco Bay area, including the Sacramento - San Joaquin River Delta, in 1955, was $13,500,000 to $18,300,000. The sport fishery was estimated to have an annual value of about $50,000,000. Since 1955, these resources have undoubtedly been further depleted. Recreationists have been confronted with nuisance odors and degradation of the esthetic enjoyment of the streams.

The man caused pollution problem in the San Joaquin River system steadily grows more acute.

The purpose of this economic evaluation is to determine the economic impact upon Stanislaus and San Joaquin water users of improvement in water quality which can be realized by storage and release of water in the New Melones Project for the purpose of water quality control. The initial step in evaluating the economic effects was to identify, and insofar as possible, quantify the net beneficial effects attributable to water quality control releases. These effects include decreases in current pollution damages to all beneficial users of water and the prevention of future additional damages attributable to increasing waste loads generated by population growth and industrial development. The effects on users of San Joaquin River water will gradually decrease downstream becoming very minor near the river's

mouth. The effects in municipal and industrial water supplies diverted from Delta channels will be minimal. Pollution damages may be roughly grouped into two categories, tangible and intangible, and their reduction used as a measure of the economic value of water quality control.

Basis for Appraisal

In the economic evaluation of water pollution control, it is essential that evaluation take place within a specified framework of physical and economic conditions. For purposes of this analysis, these conditions are as set forth in Appendix A.

Early in the study, it was apparent that maintenance of the quality of the water in the lower Stanislaus River at an adequate level to support the fishery, recreation, and other water uses of the Stanislaus River and improvement in the quality of San Joaquin River water will have numerous beneficial effects both in the Stanislaus River and in the lower San Joaquin River Basin. Many of these effects are very difficult to trace, quantify, and to evaluate. Some of the effects are obviously much more important economically than others. It was decided that monetary evaluation effort would be directed toward those effects that have the greatest economic impact and that other effects would be identified and discussed qualitatively.

Due to the uncertainties involved in predicting water quality and in tracing its effects, monetary estimates of the beneficial effects should be considered in terms of their order of magnitude rather than as sharply defined forecasts. Throughout the study, efforts were made to establish conservative estimates. It is, therefore, believed that the actual results will be at least as great as the estimates indicate.

For monetary evaluation, the study distinguishes two broad categories of water use; namely, (1) fishery use of the lower Stanislaus River water and (2) agricultural use of San Joaquin River waters below the mouth of the Stanislaus River. The net beneficial effects of improvement in the quality of water for these uses resulting from water quality control releases from New Melones Reservoir are discussed in the following paragraphs.

Fishery Benefits

The fishery resource of the Stanislaus River, below the proposed New Melones Dam, has been subjected to damage from upstream

depletion of flows and from pollution of the stream by discharge of organic wastes. Discharge of organic wastes to the stream exerts a bio-chemical demand for the dissolved oxygen in the water. When the waste discharged is sufficient to deplete the available dissolved oxygen in the stream below a specified level, the fish suffocate. Currently, this problem is restricted to the late summer months of dry years when normal waste discharges, augmented by wastes from food processing plants, are relatively high and the flow of the stream is low. Due to the projected growth of population and industrial development in the area, discharging treatment plant effluents to the river, and further depletion of stream flow, the future problem of maintaining the dissolved oxygen content of the water suitable for the fish will intensify.

Fish are also affected by water temperatures and substances such as pesticides, which are toxic to them. The proposed schedule of water releases from the dam required to provide the fish with an adequate quantity of water is expected to also control water temperatures within the tolerance limits of the fish species involved. Discharge of toxic materials to the stream in sufficient quantities to be lethal to fish or other forms of beneficial life is prohibited. While pollution of the stream by materials toxic to fish life does inadvertently occur, the future frequency of such occurrences and resulting damages can not be quantified.

Studies of the present and future quality of Stanislaus River waters by the U. S. Public Health Service and consultation with personnel of the U. S. Fish and Wildlife Service and State Department of Fish and Game indicate that the primary water quality problem likely to significantly affect the fishery resource in the future is the dissolved oxygen content of the waters. This quality parameter was, therefore, selected for use in estimating water quality control benefits resulting from protection of the fishery resource.

Projected waste loads discharged to the stream after adequate treatment, are not expected to deplete the dissolved oxygen in the streams below the damage threshold level except during the months of June, July, August, and September. The anadromous fish spawning beds in the Stanislaus River below New Melones Damsite are generally located above the points of waste discharge of the urbanized areas and will not be affected by such discharges. Since the dissolved oxygen levels are expected to be adequate during the period of the spring and fall anadromous fish runs, the fishery resource expected to be significantly damaged by the low dissolved oxygen levels during July, August, and September, is the warm water fishery. There is some conjecture that a winter run of steelhead and salmon may be re-established in the Stanislaus River. If this run should materialize, it would also be affected by low dissolved oxygen during the

July-September spawning period.

The U. S. Fish and Wildlife Service estimated the future annual recreational value of the warm water fishery to be $45,000 in 1970 increasing to $235,000 in 2020 and averaging $140,000 over the period. These values are dependent upon providing an adequate quantity of water in the stream to support the fishery, improvement in public access to the stream, and increasing use of the stream resulting from population growth. Extension of the same rate of increase in value to the year 2075 results in an annual value of about $445,000 in 2075. While it is difficult to establish the maximum potential number of fishermen days the stream could ultimately provide, the Fish and Wildlife Service believes the maximum potential value of the warm water fishery will not be reached by 2075.

Realization of the above estimated warm water fishery values is dependent upon maintaining the quality of the water as well as the quantity of water required. In developing estimates of the need for and value of water required for water quality control to support the fishery, the following procedure was adopted.

During discussions with U. S. Fish and Wildlife Service personnel, a dissolved oxygen level of 5 mg/l was established as the minimum concentration the fish could tolerate without damage. Damage to the fishery is expected to result if the dissolved oxygen concentration is allowed to fall below 5 mg/l. Severity of the damage would increase as the dissolved oxygen level fell below the 5 mg/l level until the entire fish population in the reach of the river affected was destroyed. The damage factors shown in Table 11 were used.

The Fish and Wildlife Service estimates that it takes two years for a fishery that is completely destroyed to return to normal and that the rate of return is one half of the normal fishery per year. Thus, if a fishery was 50 percent destroyed, it would fully recover in one year.

Using the above damage factors and recovery rate, the damage which would occur in the affected reach of the Stanislaus River if only pre-project flows and requested fish releases are in the stream was determined for five points in time 1975, 2000, 2025, 2050, and 2075. For each point in time, flows for each of the 25 years in the study period were used in estimating damages. The average annual rate of damages which can be expected was determined for each point in time by multiplying damages occurring during each of the years in the study period by its probability of occurrence and summating the products. Damages to the fishery resource which would occur with the recommended water quality releases was determined in the same manner.

The differences in damages represents the water quality control benefits resulting from protection of the fishery resource of the stream. See the appendix for greater detail.

The annual rate of water quality control benefits, resulting from protection of the fishery resource at 25 year intervals and the present annual equivalent value of the future benefits, are shown in Table 12 at the end of the Water Quality Control Benefits section. The present value of benefits accruing during the 100 year evaluation period is estimated to total $794,000. The present annual equivalent value of these benefits is $26,000.

TABLE 11

ESTIMATED FISHERY DAMAGES
FROM LOW DISSOLVED OXYGEN
CONCENTRATIONS

Dissolved Oxygen Concentration mg/l	Damage Factor Percent Destroyed
5.0 and above	00
4.5 to 4.9	05
4.0 to 4.4	15
3.5 to 3.9	30
3.0 to 3.4	60
below 3.0	100

Agricultural Benefits

Agriculturalists, diverting irrigation water supplies from the San Joaquin River below the mouth of the Stanislaus River, have been adversely affected by the salinity content of their water supplies. The concentration of total dissolved solids in the river, as measured at the Vernalis Gage, has shown a consistent upward trend during recent years, see Figure 4 in the Appendix. During some months, when demand for irrigation water is large, the concentration of total dissolved solids has exceeded 1000 milligrams per liter.

Eleven categories of economic costs associated with excessive salinity in irrigation water supplies have been recognized in semi-arid regions. They are as follows:

1. Costs of increased quantities of water required for leaching and/or dilution of salinity concentration in existing irrigation supplies to prevent accumulation of excessive salts in the soil.

2. Costs of applying quantities of water required for leaching.

3. Increased costs of drainage to remove and dispose of water applied for leaching.

4. Fertilizer losses caused by leaching.

5. Costs of laboratory testing to insure maintenance of salinity concentrations in the soil solution within crop tolerance limits.

6. Excessive corrosion of metal irrigation facilities.

7. Replanting costs due to seed germination and plant establishment failures due to excessive salinity of surface soils.

8. Reduction in crop yields resulting from salinity damage to growing crops including physiological damage to trees in established orchards.

9. Increased costs of irrigation due to forced changes in method of irrigation.

10. Forced substitution of low salt tolerant crops for high value salt sensitive crops due to excessive salinity in irrigation water supplies.

11. Destruction of agricultural productivity of irrigated land due to excessive accumulation of salinity and associated water logging.

The physical problems involved in the above eleven categories are well documented in the literature. Specific monetary evaluation of these effects, however, has been generally neglected.

In the production of irrigated crops, care must be given to avoid accumulation, in the root zone, of excessive concentrations of salt left behind by the evapo-transpiration of the irrigation water through natural soil drainage or man-made drainage systems to disposal areas. Where soil drainage is poor, the higher the concentration of salts in the irrigation water, the greater the problems are likely to be. Salt accumulation in the root zone may be prevented by applying enough water to leach the salts from the soil. For a given crop and soil the quantity of water required for leaching and salt disposal varies directly with the relationships between the cations and anions in solution, their precipitation and solubilization, and exchange reactions in the soil; and the concentration of the salts in the irrigation water supply.

The difference in the quantity of water required for leaching provides a basic parameter for estimating the economic impact upon agriculture of improvement in the quality of irrigation water supplies attributable to water quality releases from the proposed New Melones Project. Proceeding with this basic concept, a method for the monetary evaluation of decreases in salinity concentration of irrigation water supplies was developed.

In general, the procedure involved the determination of the increases or decreases in the weighted mean concentration of salinity in irrigation water diverted from the lower San Joaquin River under with and without project conditions for each of the 25 years in the study period and the determination of the differences, in acre feet, of water required for leaching of the salts. These differences were then multiplied by the imputed economic value per acre foot of water consumptively used by agriculture and summated to obtain an estimate of the net salinity pollution control benefits. Figure 6 shows the annual economic impact on agriculture that the various releases from New Melones would have during the 1921-46 hydrologic study period under 2025 conditions of development.

In this report, the imputed economic value of water consumptively used (the portion of the water actually applied to crops that is lost by evapo-transpiration) is $20.00 per acre foot. Based upon a farm irrigation efficiency of 75 percent, this value would be equal to $15.00 per acre foot for irrigation water delivered to the farm headgate. The irrigated areas served by water diverted from the lower San Joaquin River consist of organic and mineral soils that are considered to be some of the most productive soils in the State of California. The use of $20.00 per acre for water consumptively used is, therefore, considered conservative. For detail on methodology and basis for estimates used in this report, see "Appendix B - Economics" and "Appendix C - Consultant's Evaluation," of the report,

"Water Quality Control Study, Peripheral Canal, Sacramento - San Joaquin Delta, California" by the U. S. Department of Health, Education, and Welfare, Public Health Service, Region IX, San Francisco, California (12)(13).

Under project conditions, the future median flow of the San Joaquin River, at the Vernalis Gage, was estimated by the Bureau of Reclamation to be 1,675,000 acre feet. For purposes of analysis, it is estimated, that of this flow, the following mean quantities will be diverted annually for irrigation use:

1975	908,000 acre feet
2000	954,000 acre feet
2025	1,000,000 acre feet
2050	1,039,000 acre feet
2075	1,077,000 acre feet

The increase in irrigation diversions with time is due, generally, to increased utilization of San Joaquin water on the present irrigated acreage rather than an expansion of the irrigated area.

Estimates of the net agricultural salinity control benefits, attributable to water quality releases from the New Melones Project were developed for the beginning year of each 25 year interval up to the year 2075. The beginning year of project operation is estimated to be 1975. The total present value of the future benefits were then computed and converted to an annual equivalent value by the use of standard discounting procedures. The estimated total present value of agricultural salinity control benefits accruing during the 100 year evaluation period is $4,824,000. The present annual equivalent value is $158,000, Table 12. A portion of these benefits result from the additional quantities of water that are released from New Melones for DO control and this water must remain in the river until it reaches Vernalis, if the benefits are to be realized.

Intangible Benefits

In addition to the evaluated effects, resulting from water quality control, other beneficial effects, which have not been evaluated monetarily, will also accrue. These effects are briefly described as follows:

1. Maintenance and enhancement of the quality of the water in the Stanislaus River will be beneficial in providing a stream esthetically beautiful and suitable for a wide variety of recreational uses in addition to fishing.

2. High quality water released from New Melones Dam will be discharged to the San Joaquin River and will be instrumental in improving the quality of the San Joaquin River waters for all downstream beneficial uses. The non-evaluated uses include the resident and anadromous fishery, recreation, municipal and industrial. While the physical improvement in quality parameters pertinent to each of these uses will not be very large and will not result in a satisfactory solution to the pollution problem in the lower San Joaquin River, the beneficial effects will be significant because of the widespread and intensive uses made of the river and the Sacramento - San Joaquin Delta. Water quality releases from New Melones Project should be considered as a partial contribution to the overall solution of the pollution problem in the San Joaquin River rather than as a solution of the entire problem.

The inclusion of the water quality control purpose in the New Melones storage project and the storage and release of water for water quality control will result in significant benefits to all water users in the Stanislaus River and lower San Joaquin River Basins. The present value of the evaluated water quality control benefits resulting from protection of the fishery resource in the Stanislaus River and improvement in the quality of irrigation water diverted from the lower San Joaquin River during the 100 year evaluation period, is estimated to total $5,618,000. This is equal to a present annual equivalent value of $184,000, Table 12. In addition to these evaluated benefits, significant intangible benefits will also accrue to recreationists using the Stanislaus River and to sport and commercial fishermen, recreationists, industrial and municipal users of the lower San Joaquin River waters, and to the health and well-being of the general public in these areas.

Identification of Beneficiaries

Benefits resulting from providing water for water quality control in the New Melones Project will be widespread. They will accrue to hundreds of thousands of people utilizing, for a wide variety of purposes, the reach of the Stanislaus River from the proposed damsite to its mouth and the reach of the San Joaquin River from Vernalis to its mouth, a total stream distance of 148 miles. The estimated irrigation diversions from the San Joaquin River in the year 2025 of 1,000,000 acre feet is equivalent to a full supply of irrigation water for about 330,000 acres. Recreational and sport fishery

use of the Sacramento - San Joaquin Delta is currently estimated at 2,780,000 recreation days annually and is projected to reach 13,878,000 recreation days annually by the year 2020 (14). Over half of this recreational use may be attributable to the San Joaquin River portion of the Delta. Although it is impossible to identify benefits accruing to any single individual, such benefits are likely to be very small. The reaches of the streams affected provide outdoor recreation for visitors residing in other areas of California and in other states of the Nation as well as local residents. Agricultural and industrial commodities produced in the area are distributed throughout the nation.

TABLE 12

WATER QUALITY CONTROL BENEFITS
NEW MELONES PROJECT

FUTURE ANNUAL BENEFITS

Year	Fishery (dollars)	Agriculture (dollars)	Total (dollars)
1975	300	142,400	142,700
2000	2,900	150,000	153,000
2025	46,000	168,300	214,300
2050	130,000	198,800	328,800
2075	201,000	257,700	458,700

PRESENT VALUE OF FUTURE BENEFITS (1)

Year	Fishery (dollars)	Agriculture (dollars)	Total (dollars)
1975	9,200	4,346,800	4,356,000
2000	55,100	163,200	218,300
2025	389,100	164,300	553,400
2050	284,900	103,400	388,300
2075	55,500	45,900	101,400
Total Present Value	793,800	4,823,600	5,617,400
Rounded	794,000	4,824,000	5,618,000
Present Annual Equivalent Value	26,000	158,000	184,000

(1) Assumes 1975 first year of project operation; evaluation period 100 years interest rate 3 1/8 percent.

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APPENDIX A

DETERMINATION OF DRAFT ON STORAGE FOR WATER QUALITY CONTROL

APPENDIX A

DETERMINATION OF DRAFT ON STORAGE FOR WATER QUALITY CONTROL

The quality of additional water that must be released from storage was determined for both total dissolved solids (TDS) and dissolved oxygen (DO) control. It was assumed that the fish release schedule requested by the U. S. Fish and Wildlife service (see Table 9) would be made. Then the additional predicted releases needed to maintain a mean monthly TDS concentration of 500 mg/l at Vernalis were determined on a month by month basis from historical data provided by the U. S. Bureau of Reclamation. The study period used was from 1921-22 to 1945-46 and the data had been adjusted by the Bureau to reflect Pre-East Side condition of development. In determining monthly releases necessary for DO control, it was assumed that fish and TDS control releases would be made and would be used to provide all or part of the DO requirement prior to making additional releases for this purpose.

Draft on Storage

All water released from New Melones can not be considered as draft on storage since under present conditions of development a portion of this water would be in the stream due to spills from the existing Tri-Dam Project.

These spills are considered as available from the stream. The quantity of spills was given on a month-by-month basis for the study period in the Bureau of Reclamation data. It was assumed spills during a month would be used first to satisfy all or part of the fish release, secondly to satisfy all or part of the TDS control release, and finally, to satisfy all or part of the DO control release.

In addition, it was considered that under New Melones project conditions without water quality releases concentration at Vernalis, weighted according to the quantity of monthly diversions for agricultural use, should be equal to present conditions. This concentration would be somewhat worsened by the project because the Tri-Dam spills, occurring mostly in March - June, provide large quantities of low TDS concentration water at Vernalis. The fish releases overcome much of this degradation but there is still a small increment (about 6 mg/l of TDS) that would have to be overcome by additional releases from New Melones. The ability to control the water in New Melones and the fact that the TDS concentration is weighted to reflect periods of extensive agricultural use would enable the project to provide an equivalent quality of water with a much smaller quantity than presently spills from the Tri-Dam Project.

The total flows needed for water quality control during the historical period and the amount that must come from storage are shown in Table A-4 for projected conditions in 1975, 2000, 2025, 2050 and 2075.

The basic data used for determining the draft on storage needed to maintain a mean monthly TDS concentration below 500 mg/l at Vernalis was provided by the Bureau of Reclamation. This data gives expected flows and TDS concentrations at Vernalis and Tri-Dam Project spills for the 1921-22 to 1945-46 historical record adjusted to Pre-East Side conditions of San Joaquin Basin water resources development and water use. Pre-East Side conditions include current development in the basin plus additional developments on the Tuolumne, Merced, Chowchilla, and Fresno Rivers. This is presumed to be the "pre-project condition." Modifying pre-project development in the basin by the addition of New Melones operation is assumed to be the project condition.

The following assumptions were made:

(1) The months of irrigation are February through November. A low TDS concentration is not needed in December or January; so no need for releases is projected.

(2) The flow versus TDS curve and the Bureau of Reclamation projection of flows in the San Joaquin River under project conditions will occur.

(3) The water released from Goodwin Dam or stored in New Melones will have a TDS concentration of 50 mg/l.

(4) The existing diversions from the Stanislaus River below Goodwin Dam will remain the same in the future.

(5) The fish release schedule requested by the U. S. Fish and Wildlife Service will be met (as shown in Table 9).

The portion of this flow due to Tri-Dam Project spills (at 50 mg/l of TDS) was subtracted from the flow concentration at Vernalis to determine TDS concentration at Vernalis without the spills:

$$(TDS)_{V-TD} = \frac{Q_V\,(TDS)_V - Q_{TD}\,(50)}{Q_V - Q_{TD}}$$

Where Q denotes flow at Vernalis (V) or Tri-Dam (TD) and TDS denotes mg/l of TDS.

Note that this method includes uncontrolled flow (natural runoff, ground water outflow, and return irrigation flows) in the Stanislaus River as a portion of the remaining flow at Vernalis.

Then, on a month-by-month basis for the study period, the total amount of water necessary to release from New Melones was determined from the following equation:

$$Q_{NM} = \frac{Q_V - TD}{450} \left[(TDS)_{V-TD} - 500 \right]$$

As mentioned, this total release from New Melones includes spills, fish releases, and any other obligated releases as well as releases for water quality control.

Two refinements that will have some affect on TDS at Vernalis were not quantified but errors resulting from not doing so would probably be negligible. These items are: (1) The future affect of M & I waste effluents returning to the Stanislaus was ignored. The average TDS increment picked up in municipal use is variable and cannot be predicted too closely but with a present M & I TDS concentration of about 300 mg/l the range of TDS in the effluent will probably be from 300-500 mg/l. Since this is not a great deal different than that at Vernalis the diluting power of the effluent would probably not be great; (2) The effect of diversions along the Stanislaus was not computed. Stanislaus River diverters would benefit from New Melones releases during July - October since the quality of water (a mixture of releases and accretions) in the river will be somewhat better than under present conditions where virtually all the water in the stream is from accretions. This would result in a poorer quality of water in the San Joaquin River, particularly if the amount of Stanislaus diversions increase. An increase in Stanislaus River diversions would also reduce the quantity of outflow from the Stanislaus, and although the diversion might come from pre-project stream flow it will be necessary to replace any increased diversions by releases from New Melones if these projections are to remain valid.

This method is considered a satisfactory approximation for predicting future TDS concentrations and quantities of dilution water needed, although it is recognized that assumptions made may not be valid in the future. Using a TDS concentration at New Melones of 50 mg/l is conservative since under present condition at Tulloch Reservoir the samples taken have a median value of 41 mg/l and significant degradation in the future does not appear likely.

These determinations of future flows, concentration, and water needs will be in error if any of the future conditions do not materialize as predicted. The more uncertain assumptions are: (1) flows at Vernalis under Pre-East Side conditions of water resource development and water use; (2) concentrations of TDS at Vernalis for given flows; (3) future diversion practices on the Stanislaus River; and (4) other releases (besides fish and water quality control) from New Melones.

DISSOLVED OXYGEN CONTROL

The total quantities of water needed to insure a minimum concentration of 5 mg/l Dissolved Oxygen in the Stanislaus River were estimated from data concerning present conditions on the stream and from projections of the future waste load. No analyses was made of the flows needed for DO control in the San Joaquin River or the Delta for the following reasons:

1. The most certain and economical means of controlling the complex pollution problem in the Delta is not known at this time. Furthermore, if dilution is the answer it is probable that the quantities needed would be large compared to the yield of New Melones.

2. If low DO concentrations exist in the San Joaquin below the Stanislaus they undoubtedly exist upstream since the source of pollution would be upstream on either the Tuolumne or San Joaquin Rivers. Thus, New Melones water would solve only a segment of the problem. Also, the quantities of water needed would be large since in 2 years out of 3 the dry weather flow in the San Joaquin is over 10 times the projected Stanislaus outflow under assumed New Melones project conditions (fish releases and TDS control releases).

It is recognized that if an extra amount of water is released to the Stanislaus from New Melones it will have a small benefit to the fishery in the lower San Joaquin and the Delta but the magnitude of this benefit has not been evaluated.

Magnitude of Waste Load

The population projection has been given in the main body of the report for the years 1975, 2000, 2025, 2050, and 2075. In addition, the industrial employment was predicted and daily pollution loads in pounds per capita per day of ultimate BOD and water usage in gallons per capita day were assigned to different types of industries. These values are shown in Table A-1. For a more complete discussion of the unit waste loading values, see reference 6 in the bibliography. The projected monthly water quality control releases are shown in Table A-3 in cubic feet per second and the TDS + DO draft on storage and total releases are shown in Table A-4.

Summary of Assumptions

The assumptions used in making these projections are listed here and discussed in more detail below.

(1) The waste output from cannery operations follows a fixed monthly pattern and occurs between July 1 and October 31.

(2) Municipal and industrial wastes are treated together at two centrally located points:

(a) Riverbank, which would receive wastes from Oakdale, Escalon and Riverbank areas; (b) Ripon, which would receive wastes from the Ripon and Salida areas.

(3) Secondary treatment will be provided and some ponding capacity will be available. A removal of at least 85% of the ultimate first stage BOD will be provided in 1975 and this will increase to 90% in 2000 and beyond. The DO concentration in the effluent will be 1 mg/l in 1975 and 3 mg/l in 2000 and beyond. These effluent standards are considered "adequate" treatment and must be met before releases for water quality control can be made.

(4) Disposal will be to the Stanislaus River. (Disposal by ponding, irrigation use, and discharge to a master drain was also considered).

(5) The present hydrologic and irrigation conditions which result in accretions along the Stanislaus River will not be altered.

(6) The fish release schedule requested by the U.S. Fish and Wildlife Service will be made.

(7) The releases necessary to limit TDS in the flows of the San Joaquin River at Vernalis to 500 mg/l on a mean monthly basis during the irrigation season will be made.

(8) Temperature and natural DO concentrations in the Stanislaus River will not be altered.

(9) Between the Riverbank discharge and McHenry Bridge, the biochemical oxygen demand and dissolved oxygen relationships observed during recent State field surveys, will continue.

(10) Reaeration and accretions between McHenry Bridge and Ripon will be sufficient to return the DO concentration in the stream to natural conditions.

(11) The Ripon waste load will be smaller than the Riverbank waste load and no additional dilution water will be required.

(12) The effect of algal photosynthesis and respiration on the DO concentration is not estimated.

TABLE A - 1

PROJECTED UNIT WASTE LOAD AND WATER USAGE
STANISLAUS RIVER BASIN

	Waste Load lbs/capita day Ultimate 1st Stage BOD	Water Use gallon per capita day (gpcd)	Amount Water Assumed to return to Stream or go to Treatment Plant (gpcd)
Domestic Use	0.30	250	200
Industrial Use			
Food and Kindred	25	3500	3000
Chemical & Allied	7	3500	3000
Other Non-Durable	6	125	100
Other Manufacturing	0.5	125	100
Services	0.03	10	10

It was assumed that wastes from the Riverbank - Oakdale - Escalon area would be treated and discharged at Riverbank and that Ripon - Salida area wastes would be treated and discharged at Ripon.

The canning season (food and kindred industry) operates for a season of about 120 days, assumed to be from July 1 to October 31. Its waste output is not constant and a typical variation was used. It was assumed that 15% of the annual load occurs in July, 50% in August, 25% in September, and 10% in October. The non-cannery waste load can be considered as the base load and the peak cannery load added to this is the maximum load.

Treatment and Disposal Conditions

It was assumed that secondary treatment would be provided and would remove a minimum of 85% of the influent BOD in 1975 and

90% in 2000 and beyond. It seems probable that this level can be maintained at all times by careful operation of the treatment plant and holding ponds. Also, rainfall during the months of heaviest loading (July - September) is extremely rare and therefore it is unlikely that a heavy BOD load from storm water runoff would enter the river or treatment plant during this critical time. The DO concentration in the effluent was assumed to be 1.0 mg/l in 1975 and 3.0 mg/l in 2000 and beyond. Since the ability to maintain 1 - 5 mg/l of DO in effluents from some types of treatment processes is possible at the present time, provided the plant is not overloaded and is well operated, it seems reasonable to expect that by the year 2000 a minimum DO of 3 mg/l can be maintained in the effluent at all times.

The possibility of ponding a sufficient quantity of the peak season effluent to eliminate or reduce the need for water quality control releases was investigated. It was estimated that under 2025 conditions the Riverbank treatment plant would need 1900 acre feet of storage capacity (dry year conditions) to meet the required DO concentrations without water quality control release. Providing this quantity of storage would be very costly and the water stored would be unavailable for downstream use in the time of year when there is an appreciable irrigation demand. Furthermore, the mineral quality of the effluent would be satisfactory for agricultural reuse and since it would probably have a lower TDS concentration than the San Joaquin River it would be desirable to discharge it to the Stanislaus River if the DO concentration can be kept at a satisfactory level.

The use of all or portion of the effluent for irrigation was considered. This would be acceptable for most crops if satisfactory treatment and disinfection is provided. At the present time, irrigation is extensive and most farms already have a developed irrigation supply, either from canals, wells, or the river. Also, the TDS concentration of the effluent would undoubtedly be greater than the present supply available along the Stanislaus and thus not as desirable. A need for additional irrigation water in the area is not expected to develop after the turn of the century and it appears unlikely that without a subsidy many irrigators will find the cost, quality, and esthetic factors of waste effluent attractive enough to switch from present sources.

For the above reasons, no ponding or irrigation use is assumed but it is recognized that these alternates could be used to accept a portion of the wastes and thus provide a safety factor in case future effluent waste loads are greater than predicted.

Another possibility is that the waste could be discharged to a waste drainage canal and conveyed out of the basin. There are current proposals to provide these waste drains for various areas in the valley but it is not known if any drain will be built anywhere near the Stanislaus waste disposal points. Also, this plan would remove a good quality (for irrigation) of water from the basin and make it unavailable for dilution or reuse downstream. For these reasons this alternative was eliminated.

Stream Conditions

The months where dissolved oxygen concentration is of primary concern in the Stanislaus River are July, August, and September because of the combination of lower natural stream flow, higher water temperatures, lower fish releases, and the increased waste load due to cannery operations.

As discussed in the Hydrology Section of the main body of the report there is presently a significant accretion between Goodwin Dam and Riverbank which is due to both irrigation return flows and a high groundwater table. The 1 in 5 year and 1 in 10 year low monthly flows were determined for the more critical months from a low flow frequency graph (see Figure 8). The stream data analyzed was for the 15 year period from 1949 to 1963 and included the gaging stations at Goodwin Dam, Orange Blossom Bridge, Riverbank, Ripon, and near the mouth of the Stanislaus. It was assumed that irrigation water usage and practices and groundwater levels would remain constant under project conditions and thus the quantity of accretions would remain constant.

Temperature data was available from monthly grab samples taken from the 1951 to 1963 near the mouth of the Stanislaus. Several sets of data indicate that temperatures at Riverbank are similar to those at the mouth. The median temperature for each month was assumed to occur during low flow years since an analyses of the data indicated that the water temperature variation is not particularly related to flow variation in the river. The median percent saturation is about 85% for the critical months and the product of this value and the median temperature was assumed to be the average DO in the stream. Using present water temperatures is conservative since the New Melones project would tend to lower temperatures. The values used are given in Table A-2.

TABLE A - 2

MEDIAN DISSOLVED OXYGEN CONCENTRATION
ABOVE RIVERBANK

Month	DO (mg/l)
June	8.3
July	7.6
August	7.4
September	7.6

Oxygen Demand on Stream

As mentioned in the main body of the report the current DO level drops rapidly after the Riverbank discharge, the observed low point usually occurring about 5 hours later and often returns to normal concentrations (about 85% of saturation) in 20 hours. This sag and recovery is much more rapid than would be indicated by the Streeter-Phelps equation but it is a consistent pattern during the late summer months when cannery wastes are being discharged. Similar, though slightly slower, demand and recovery characteristics are observed on the Tuolumne River from secondary treated ponded wastes discharged at Modesto.

There was not sufficient time or funds available to make a stream survey to determine the nature of the wastes and what was actually occurring below the discharge but there are several reactions that could be taking place:

1. Nitrification in the stream, that is the exertion of the nitrogenous stage BOD demand where bacteria convert ammonia to nitrites and nitrates, thus absorbing oxygen from the stream. This is common in wastes that have undergone biological treatment or have been ponded prior to discharge.

2. An oxygen demand exerted by aquatic plants such as filamentous bacteria and fungus. Extensive growths have been observed in the reach between Riverbank and McHenry Bridge.

3. Oxygen demand exerted by organic sludge deposits.

4. The rapid reaeration may be partially due to: (a) accretions occurring between Riverbank and Ripon; and (b) algal photosynthetic activity.

Due to these uncertainties a likely oxygen demand and reaeration rate was determined empirically from several sets of data. The net oxygen demand exerted between Riverbank and McHenry Bridge was assumed to be 25% of the ultimate first stage BOD demand. The pounds per day of reaeration between McHenry Bridge and Ripon is more than adequate to overcome the defecit caused by the Riverbank discharge. This approach predicts a somewhat higher demand for dilution water at Riverbank than the Streeter- Phelps equation but since the rapid demand and reaeration results in high DO levels at Ripon the larger Riverbank load is not superimposed on the Ripon discharge and no additional flow is needed at Ripon.

No data were available on nighttime DO concentrations so the effect of algae photosynthesis and respiration is not known. However, supersaturated conditions have occurred several years during July and August near the mouth of the Stanislaus so algal activity could be a problem. It is probable that the predictions from the above assumptions for DO demand will provide a sufficient quantity of dilution water to overcome the oxygen demand exerted by respiration of algal.

The total flow needed to protect against both the 1 in 5 year and the 1 in 10 year low flows was calculated from the above assumptions. The quantity of additional water (water released for water quality control) needed to protect against the 1 in 5 year low flow is somewhat less than for longer return periods primarily because this is the minimum flow at which wet year fishery releases would be available to supply a portion of the dilution water. The return period to protect against was determined after an evaluation was made of the benefits per acre foot of additional water required. It was decided that the 1 in 10 year low flow condition should be protected against. Sufficient water should be provided from New Melones to meet this criterion until at least 2025. The amounts of water needed for quality control should be thoroughly reevaluated periodically and adjusted to reflect current estimates on waste loads, treatment efficiencies, and stream assimilative capacity.

TABLE A - 3

MONTHLY WATER QUALITY CONTROL RELEASES 1/
(cubic feet per second)

	Maximum Releases From Storage 2/			
Year	June	July	August	September
1975	---	---	30	---
2000	---	---	61	---
2025	---	16	128	45
2050	3	84	230	122
2075	48	149	312	188

1/ Maximum releases needed to maintain 5 mg/l DO concentration during 10 year low flow conditions.

2/ Does not include fishery releases of 50 cfs (dry year) assumed to be released in all of above months but it does include all other releases. In wet years fish releases are 100 cfs (7 cfs is minimum increase in accretions for a wet year compared to the 1 in 10 low flow year).

TABLE A - 4

ANNUAL RELEASES FROM STORAGE
FOR WATER QUALITY CONTROL
1921-1946 Hydrologic Study Period
(1000 Acre Feet)

BASE TOTAL DISSOLVED SOLIDS RELEASES

	(1)	(2)	(3)	(4)	(5)	(6)
	Fish Release		TDS Release		To Meet Mean TDS	W/O Project
Year	Stream	Storage	Stream	Storage	Stream	Storage
1921-22	41	57	0	0		
22-23	62	36	0	0		
23-24	0	83	0	35.0		
24-25	33	51	24.0	5.5		
25-26	30	68	8.5	0		
1926-27	38	60	0	2.0		
27-28	39	59	0	2.5		
28-29	0	98	0	28.5		
29-30	23	76	12.5	48.5		
30-31	0	83	0	21.5		6.5
1931-32	30	39	13.0	12.5	1.5	
32-33	15	54	1.0	48.5	1.5	15.0
33-34	11	58	0	18.0		
34-35	27	57	6.0	0		
35-36	36	62	0	0		
1936-37	36	62	0	0		
37-38	62	36	0	0		
38-39	37	61	10.0	36.5		
39-40	44	54	6.5	0		
40-41	50	48	0	0		
1941-42	48	50	0	0		
42-43	56	42	0	0		
43-44	29	69	0	13.0		
44-45	36	62	4.0	0		
45-46	56	42	0	0		
Average	33.6	58.7	3.4	10.9	0.1	0.9
Range	0-62	36-98	0-24	0-48.5	0-1.5	0-15.0

TABLE A - 4 (Continued)

YEAR 1975

DISSOLVED OXYGEN RELEASE

Year	(7) Total Need at Riverb.	(8) Avail. From Accr.	(9) Avail. From Fish R.	(10) Avail. From TDS Releases	(11) Additional DO Needed Stream	(12) Water Storage	(13) Total Amount Released For Water Quality
1921-22	8.0	3.5	6.0	--	0	0	0
22-23	8.0	3.5	6.0	--	0	0	0
23-24	8.0	3.0	3.0	2.0	0	0	35.0
24-25	8.0	3.5	6.0	--	0	0	29.5
25-26	8.0	3.5	6.0	--	0	0	8.5
1926-27	8.0	3.5	6.0	--	0	0	2.0
27-28	8.0	3.5	6.0	--	0	0	2.5
28-29	8.0	3.5	6.0	--	0	0	28.5
29-30	8.0	3.5	6.0	--	0	0	61.0
30-31	8.0	3.0	3.0	0	0	2.0	30.0
1931-32	8.0	3.0	3.0	0	0	2.0	29.0
32-33	8.0	3.0	3.0	2.0	0	0	66.0
33-34	8.0	3.0	3.0	0	0	2.0	20.0
34-35	8.0	3.5	6.0	--	0	0	6.0
35-36	8.0	3.5	6.0	--	0	0	0
1936-37	8.0	3.5	6.0	--	0	0	0
37-38	8.0	3.5	6.0	--	0	0	0
38-39	8.0	3.5	6.0	--	0	0	46.5
39-40	8.0	3.5	6.0	--	0	0	6.5
40-41	8.0	3.5	6.0	--	0	0	0
1941-42	8.0	3.5	6.0	--	0	0	0
42-43	8.0	3.5	6.0	--	0	0	0
43-44	8.0	3.5	6.0	--	0	0	13.0
44-45	8.0	3.5	6.0	--	0	0	4.0
45-46	8.0	3.5	6.0	--	0	0	0
					Average	0.24	15.52
					Range	0 - 2	0 - 66.0

TABLE A - 4 (Continued)

YEAR 2000

DISSOLVED OXYGEN RELEASE

Year	(7) Total Water at Riverb.	(8) Avail. From Accr.	(9) Avail. From Fish Releases	(10) Avail. From TDS Releases	(11) Additional DO Water Needed Stream	(12) Storage	(13) Total Amount Released For Water Quality
1921-22	9.5	3.5	6.0	-	0	0	0
22-23	9.5	3.5	6.0	-	0	0	0
23-24	9.5	3.0	3.0	3.5	0	0	35.0
24-25	9.5	3.5	6.0	-	0	0	29.5
25-26	9.5	3.5	6.0	-	0	0	8.5
1926-27	9.5	3.5	6.0	-	0	0	2.0
27-28	9.5	3.5	6.0	-	0	0	2.5
28-29	9.5	3.5	6.0	-	0	0	28.5
29-30	9.5	3.5	6.0	-	0	0	61.0
30-31	9.5	3.0	3.0	0	0	3.5	32.0
1931-32	9.5	3.0	3.0	1.0	0	2.5	30.0
32-33	9.5	3.0	3.0	3.5	0	0	66.0
33-34	9.5	3.0	3.0	0	0	3.5	22.0
34-35	9.5	3.5	6.0	0	0	0	6.0
35-36	9.5	3.5	6.0	-	0	0	0
1936-37	9.5	3.5	6.0	-	0	0	0
37-38	9.5	3.5	6.0	-	0	0	0
38-39	9.5	3.5	6.0	-	0	0	46.5
39-40	9.5	3.5	6.0	-	0	0	6.5
40-41	9.5	3.5	6.0	-	0	0	0
1941-42	9.5	3.5	6.0	-	0	0	0
42-43	9.5	3.5	6.0	-	0	0	0
43-44	9.5	3.5	6.0	-	0	0	13.0
44-45	9.5	3.5	6.0	-	0	0	4.0
45-46	9.5	3.5	6.0	-	0	0	0
					Average	0.38	15.7
					Range	0 - 3.5	0 - 66.0

TABLE A - 4 (Continued)

YEAR 2025

DISSOLVED OXYGEN RELEASE

Year	(7) Total	(8) From Accr.	(9) From Fish R.	(10) From TDS Release	(11) Additional Stream	(12) For DO Storage	(13) Total Amount Released
1921-22	14.0	3.5	6.0	0	0	4.5	4.5
22-23	14.0	3.5	6.0	0	0	4.5	4.5
23-24	30.5	10.0	9.0	11.5	0	0	35.0
24-25	14.0	3.5	6.0	0	0	4.5	34.0
25-26	14.0	3.5	6.0	0	0	4.5	13.0
1926-27	14.0	3.5	6.0	0	0	4.5	6.5
27-28	14.0	3.5	6.0	0	0	4.5	7.0
28-29	14.0	3.5	6.0	4.5	0	0	28.5
29-30	14.0	3.5	6.0	4.5	0	0	61.0
30-31	30.5	10.0	9.0	1.0	0	10.5	38.5
1931-32	30.5	10.0	9.0	2.5	0	9.0	36.0
32-33	30.5	10.0	9.0	11.5	0	0	66.0
33-34	30.5	10.0	9.0	0	0	11.5	29.5
34-35	14.0	3.5	6.0	0	0	4.5	10.5
35-36	14.0	3.5	6.0	0	0	4.5	4.5
1936-37	14.0	3.5	6.0	0	0	4.5	4.5
37-38	14.0	3.5	6.0	0	0	4.5	4.5
38-39	14.0	3.5	6.0	4.5	0	0	46.5
39-40	14.0	3.5	6.0	0	0	4.5	11.0
40-41	14.0	3.5	6.0	0	0	4.5	4.5
1941-42	14.0	3.5	6.0	0	0	4.5	4.5
42-43	14.0	3.5	6.0	0	0	4.5	4.5
43-44	14.0	3.5	6.0	4.5	0	0	13.0
44-45	14.0	3.5	6.0	0	0	4.5	8.5
45-46	14.0	3.5	6.0	0	0	4.5	4.5
				Average		4.1	19.4
				Range		0 - 11.5	4.0 - 66.0

TABLE A - 4 (Continued)

YEAR 2050

DISSOLVED OXYGEN RELEASE

Year	(7) Total Need	(8) From Accr.	(9) From Fish Release	(10) From TDS Release	(11) Additional Stream	(12) DO Water Storage	(13) Total Release For Water Quality Control
1921-22	45.5	11.0	18.0	0	0	16.5	16.5
22-23	45.5	11.0	18.0	0	2.0	14.5	16.5
23-24	45.5	10.0	9.0	23.5	0	3.0	38.0
24-25	45.5	11.0	18.0	0	0	16.5	46.0
25-26	45.5	11.0	18.0	0	0	16.5	25.0
1926-27	45.5	11.0	18.0	0	0	16.5	18.5
27-28	45.5	11.0	18.0	2.5	0	14.0	16.5
28-29	45.5	11.0	18.0	15.0	0	1.5	30.0
29-30	45.5	11.0	18.0	15.0	0	1.5	62.5
30-31	45.5	10.0	9.0	5.0	0	21.5	49.5
1931-32	45.5	10.0	9.0	7.5	5.0	14.0	46.0
32-33	45.5	10.0	9.0	25.0	0	1.5	67.5
33-34	45.5	10.0	9.0	0	0	26.5	44.5
34-35	45.5	11.0	18.0	0	0	16.5	22.5
35-36	45.5	11.0	18.0	0	0	16.5	16.5
1936-37	45.5	11.0	18.0	0	0	16.5	16.5
37-38	45.5	11.0	18.0	0	1.0	15.5	16.5
38-39	45.5	11.0	18.0	15.0	0	1.5	48.0
39-40	45.5	11.0	18.0	0	0	16.5	23.0
40-41	45.5	11.0	18.0	0	2.0	14.5	16.5
1941-42	45.5	11.0	18.0	0	0	16.5	16.5
42-43	45.5	11.0	18.0	0	0	16.5	16.5
43-44	45.5	11.0	18.0	10.5	0	6.0	19.0
44-45	45.5	11.0	18.0	0	0	16.5	20.5
45-46	45.5	11.0	18.0	0	0	16.5	16.5
				Average	0.4	13.3	29.0
				Range	0 - 5.0	1.5 - 26.5	16.5 - 67.5

TABLE A - 4 (Continued)

YEAR 2075

DISSOLVED OXYGEN RELEASE

Year	(7) Total Needs	(8) From Accr.	(9) From Fish Release	(10) From TDS Release	(11) Additional Stream	(12) DO Water Storage	(13) Total Release For Water Quality Control
1921-22	59.0	11.0	18.5	0	0	29.5	29.5
22-23	59.0	11.0	18.5	0	4.0	25.5	29.5
23-24	69.0	14.0	12.0	27.5	0	15.5	50.5
24-25	59.0	11.0	18.5	0	0	29.5	59.0
25-26	59.0	11.0	18.5	0	0	29.5	38.0
1926-27	59.0	11.0	18.5	0	0	29.5	31.5
27-28	59.0	11.0	18.5	2.5	0	27.0	29.5
28-29	59.0	11.0	18.5	19.0	0	10.5	39.0
29-30	59.0	11.0	18.5	19.5	0	10.0	71.0
30-31	69.0	14.0	12.0	9.5	0	33.5	61.5
1931-32	69.0	14.0	12.0	9.5	11.0	22.5	60.5
32-33	69.0	14.0	12.0	32.5	1.5	9.0	76.5
33-34	69.0	14.0	12.0	3.0	0	40.0	58.0
34-35	59.0	11.0	18.5	0	0	29.5	35.5
35-36	59.0	11.0	18.5	0	0	29.5	29.5
1936-37	59.0	11.0	18.5	0	0	29.5	29.5
37-38	59.0	11.0	18.5	0	1.0	28.5	29.5
38-39	59.0	11.0	18.5	21.0	0	8.5	55.0
39-40	59.0	11.0	18.5	0	0	29.5	36.0
40-41	59.0	11.0	18.5	0	2.0	27.5	29.5
1941-42	59.0	11.0	18.5	0	0	29.5	29.5
42-43	59.0	11.0	18.5	0	0	29.5	29.5
43-44	59.0	11.0	18.5	13.0	0	16.5	29.5
44-45	59.0	11.0	18.5	0	0	29.5	33.5
45-46	59.0	11.0	18.5	0	0	29.5	29.5
			Average		0.8	25.1	41.2
			Range		0 - 11.0	8.5 - 33.5	29.5 - 76.5

DEFINITIONS AND EXPLANATIONS OF TABLES

Column Number

(1) Amount of fish release that could have been met by spills from Tri-Dam Project. Calculated on a month by month basis. After construction of New Melones, this water would have to pass through the reservoir and be released from the dam.

(2) That portion of fish release that will have to be met by storage from New Melones.

(3) The amount of projected TDS release (Pre East Side Conditions) that could have been met by Tri-Dam Spills. Spills were first used to satisfy fish releases.

(4) The remaining portion of the TDS release that would have to have come from storage in New Melones.

(5)(6) That portion of TDS releases needed to lower weighted (by agricultural diversions) mean TDS to pre project conditions after fish releases were provided.

(7) The total amount of water that must be in the river at Riverbank to maintain desired DO levels. Includes existing accretions and return flows, fish releases, TDS releases, DO releases, and any other releases. Totals of critical months only.

(8) Accretions calculated to be present during months when DO control is expected to be a problem. These months are: 1975 - August in dry years; 2000 - August in dry years; 2025 - August in all years, July and Septemper in dry years; 2050 - July, August, September in all years; 2075 - June - September in dry years, July - September in wet years.

(9) Proposed fish releases in these months.

(10) The portion of TDS water released in the appropriate months that can be used to supply some of the DO release requirement.

(11)(12) Additional releases needed for DO control. Stream is water that historically would be in the stream without the project and in addition to fish releases and TDS releases. Storage is that water which must be developed by the project.

(13) This is sum of total water that must be released at the dam to meet water quality criteria after fish releases are made. (The amount appropriately chargeable to storage however is only that in column (4) and (12).) This sum is from columns 3, 4, 5, 6, (which remain constant) and from column 11 and 12 which increases with time.

APPENDIX B

ECONOMICS

AGRICULTURE BENEFITS

APPENDIX B

ECONOMICS

AGRICULTURE BENEFITS

The accumulation, in the root zone, of excessive concentrations of salts through evapo-transpiration is detrimental to the production of agricultural crops. Salt accumulation in the root zone is prevented by applying enough water to leach the salts from the soil. The quantity of water required for leaching and salt disposal varies directly with the total dissolved solids content of the irrigation water applied.

The difference in the quantity of leaching water required to maintain a fixed leachate concentration provided the basic parameter for estimating the economic impact on agriculture. Differences in the quantity of water required for leaching was priced on the basis of its alternative value when used consumptively in the production of irrigated crops. The value obtained by multiplying differences in quantity of leaching water by the economic value, is used to approximate the minimum effect on net farm income resulting from increases or decreases in farm operating costs and crop yields due to excessive salinity in irrigation water supplies.

The estimate of the parameters used in this analysis are as follows:

1. Total dissolved solids in irrigation water supplies. The weighted mean qualities of water at Vernalis under future conditions with and without the project for each year of the 25 year hydrologic study period were established as described in the Engineering appendix.

2. Concentration of total dissolved solids in the leachate. The average concentration in the leachate which could be expected and still maintain the concentration in the soil solution sufficiently low to maintain crop yields was estimated at 3,000 mg/l.

3. The economic value of water to agriculture per acre foot of water consumptively used in the evapo-transpiration process was estimated at $20.00 per acre foot.

4. Quantity of irrigation water used was estimated on the basis of irrigated acreage in service area.

The mathematical equations used are as follows:

$$L = \frac{C_1}{C_2}$$

Where

L = Proportion of irrigation water applied required for leaching

C_1 = Concentration of total dissolved solids in irrigation water supply expressed as milligrams per liter.

C_2 = Concentration of total dissolved solids in the leachate expressed as milligrams per liter.

Then

$$V = (L_1 - L_2)\ (P)\ (Q)$$

Where

V = Economic impact on agriculture due to differences in quality of irrigation water supplies expressed as dollar value.

L_1 = Proportion of irrigation water applied required for leaching under without project conditions.

L_2 = Proportion of irrigation water applied required for leaching under with project conditions.

P = Economic value of water per acre foot consumptively used.

Q = Total quantity of irrigation water used.

When L_2 is less than L_1, V will be a measure of the benefit.
When L_2 is greater than L_1, V will be a measure of the detriment.

For more detail on methodology and parameter estimates reference is made to Appendix B and C of the Peripheral Canal report (12).

DISCUSSION OF BENEFITS

Water quality control benefits shown in the report are net mean annual benefits. They were arrived at by assuming that each of the years of the hydrological cycle encompassed in the 25 year hydrologic study period would have equal weight at each of the future 5 points in time. The actual water quality releases required and the actual benefits realized on a year to year basis will vary quite widely from these means. The yearly benefits are shown in Table B-1.

With only the fish releases the weighted mean quality of irrigation diversions would be slightly lower than they would be under without project conditions, (thus the TDS concentration would be higher) and would result in increased salinity damages attributable to the project. To mitigate these remaining damages will require additional releases averaging about 1,000 acre feet annually. Water releases over and above the fish releases and the damage mitigation releases will result in net improvement in water quality. The benefits shown are net benefits resulting from improvement in quality over without project quality.

TABLE B - 1

YEARLY BENEFITS AND DETRIMENTS TO AGRICULTURE
WITH FISH AND WATER QUALITY CONTROL RELEASES
NEW MELONES PROJECT, CALIFORNIA

Hydrologic Study Period Years	1975		2000		2025	
	Detriment Dollars	Benefit Dollars	Detriment Dollars	Benefit Dollars	Detriment Dollars	Benefit Dollars
1921-22	199,762		209,920		213,394	
22-23	145,282		152,669		160,056	
23-24		532,693		559,779		586,865
24-25	423,732		445,278		453,499	
25-26		36,320		38,167		66,703
1926-27	242,148		254,461		260,091	
27-28		102,896		108,128		133,367
28-29		653,767		687,010		720,252
29-30		774,841		814,240		853,639
30-31		1,906,821		2,010,152		2,127,424
1931-32	60,528		63,606		46,696	
32-33		1,464,911		1,539,398		1,613,885
33-34		980,669		1,036,888		
34-35	599,287		629,759		640,224	
35-36	435,845		458,006		466,843	
1936-37	90,801		95,418		80,028	
37-38	54,481		57,251		53,339	
38-39		671,927		706,093		740,259
39-40	278,450		292,609		286,760	
40-41	260,308		273,544		280,098	
1941-42	133,187		139,959		140,049	
42-43	102,896		108,128		93,353	
43-44		60,546		63,625		66,703
44-45	411,619		432,549		440,154	
45-46	187,668		197,210		186,745	
	3,625,994	7,185,391	3,810,367	7,563,480	3,801,329	8,009,482
Mean	145,040	287,416	152,415	302,539	152,053	320,379
Net Benefit		142,376		150,124		168,326
Rounded		142,400		150,100		168,300

TABLE B - 1 (Continued)

Hydrologic Study Period Year	2050 Detriment Dollars	2050 Benefit Dollars	2075 Detriment Dollars	2075 Benefit Dollars
1921-22	214,684		215,460	
22-23	131,578		114,905	
23-24		637,132		739,739
24-25	429,388		409,374	
25-26		124,659		186,739
1926-27	249,318		244,202	
27-28		157,901		244,181
28-29		754,893		847,490
29-30		900,329		998,312
30-31		2,243,862		2,449,069
1931-32	27,716			86,184
32-33		1,689,815		1,917,594
33-34		1,177,342		1,249,668
34-35	637,153		617,659	
35-36	457,083		445,291	
1936-37	62,330		43,092	
37-38	48,472		43,092	
38-39		782,588		876,211
39-40	277,013		258,552	
40-41	277,034		272,923	
1941-42	124,659		114,97	
42-43	76,187		50,2	
43-44		110,822		222,635
44-45	429,367		409,	
45-46	166,212		136, 2	
	3,608,194	8,579,343	3,375,589	9,817,822
Mean	144,328	343,174	135,024	392,713
Net Benefit		198,846		257,689
Rounded		198,800		257,700

INCREMENTAL BENEFITS

On Tables B-2 and B-3, the incremental benefits per acre foot of storage water required for quality control are shown. In the column headed "Base Rate" both the future benefits and the present value of the future benefits are shown for the initial increment of storage water required, 11,100 acre feet in 1975. The present annual value of the mean annual release of the initial increment over the 100 years is $13.58 per acre foot. In columns headed "incremental" the future benefits per acre foot resulting from the additional increments of storage releases at the time they are required and the present value of future benefits are shown.

The New Melones project is located in a water short area and increments of water required in the future for water quality control could be used for other purposes during the long intervals of time unitl they are needed for water quality control. Since the beneficial use of water for other purposes and the integration of water quality control needs with needs of other purposes is the responsibility of the construction agency, no attempt was made to evaluate the benefits which could be obtained from interim use for other purposes of the future increments of water required for quality control. It is assumed that the construction agency will fully reflect integration and timing of the future needs for and value of water for all purposes in their multipurpose project analyses.

TABLE B - 2

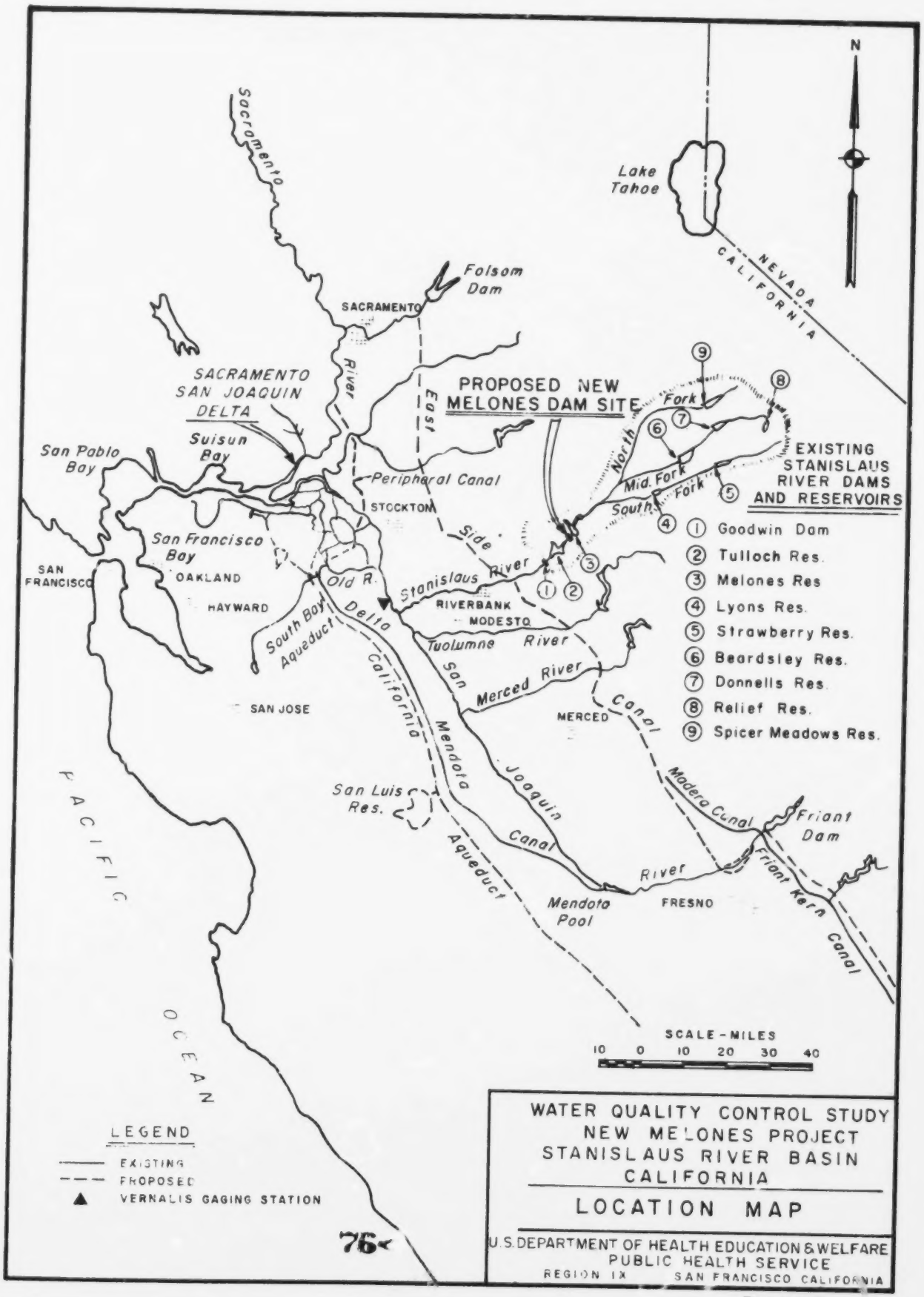
FUTURE ANNUAL INCREMENTAL BENEFITS FROM
STORAGE RELEASE FOR WATER QUALITY CONTROL
NEW MELONES PROJECT, CALIFORNIA

Year	Net Draft on Storage		Future Annual Benefits				
	Total Mean Annual	Mean Incremental	Total		Per Acre Foot		
			Base Rate	Incremental	Base Rate	Incremental	Average
	1000's of acre feet		dollars				
1975	11.1	11.1	142,700	142,700	12.86	12.86	12.86
2000	11.3	0.2	150,000	3,000	13.51	15.00	13.54
2025	15.0	3.7	157,200	54,100	14.61	14.62	14.29
2050	24.2	9.2	163,300	108,400	14.71	11.78	13.58
2075	36.0	11.8	168,600	124,600	15.20	10.56	12.74

TABLE B - 3

PRESENT ANNUAL EQUIVALENT VALUE OF FUTURE BENEFITS
FROM STORAGE RELEASES FOR WATER QUALITY CONTROL
NEW MELONES PROJECT, CALIFORNIA

Year	Net Draft on Storage		Present Annual Equivalent Value of Future Benefits				
	Total Mean Annual	Mean Incremental	Total		Per Acre Foot		
			Base Rate	Incremental	Base Rate	Incremental	Average
	1000's acre feet		dollars				
1975	11.1	11.1	142,700	142,700	12.86	12.86	12.86
2000	11.3	0.2	147,768	2,083	13.31	10.42	13.26
2025	15.0	3.7	149,897	16,001	13.50	4.32	11.20
2050	24.2	9.2	150,575	12,044	13.56	1.31	7.47
2075	36.0	11.8	150,710	3,184	13.58	.27	5.11



WATER QUALITY CONTROL STUDY
NEW MELONES PROJECT
STANISLAUS RIVER BASIN
CALIFORNIA

LOCATION MAP

U.S. DEPARTMENT OF HEALTH EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION IX SAN FRANCISCO CALIFORNIA

FIGURE 1

Middle
San Joaquin River
Salmon Slough
Old River
Paradise Cut
SOUTH SAN JOAQUIN
IRRIGATION DISTRICT
MANTECA
99
120
50
TRACY
BANTA CARBONA INTAKE
RIPON
River
RIPON GAGING STA
SALIDA
MODESTO
BANTA CARBONA IRRIGATION DISTRICT
BANTA CARBONA I.D.
BOUNDARY
VERNALIS GAGING STATION
San Joaquin
Stanislaus
Hetchy
IRRIGA
Delta
Mendota
Hetch
MODESTO
DI
River
Tuolumne
Canal

Farmington Reservoir
Woodward Reservoir
Goodwin Dam
River
KNIGHTS FERRY
H SAN JOAQUIN
ESCALON
ATION DISTRICT
OAKDALE
ORANGE BLOSSOM BRIDGE GAGING STA.
Stanislaus
OAKDALE
IRRIGATION
River
RIVERBANK GAGING STA.
RIVERBANK
Aqueduct
RIPON GAGING STA.
SALIDA
MODESTO
DISTRICT
Modesto Reservoir
Hetchy
IRRIGATION
MODESTO
DISTRICT
River
Tuolumne
River
WATER
STANISLA
U.S. DEPARTM
REGION IX

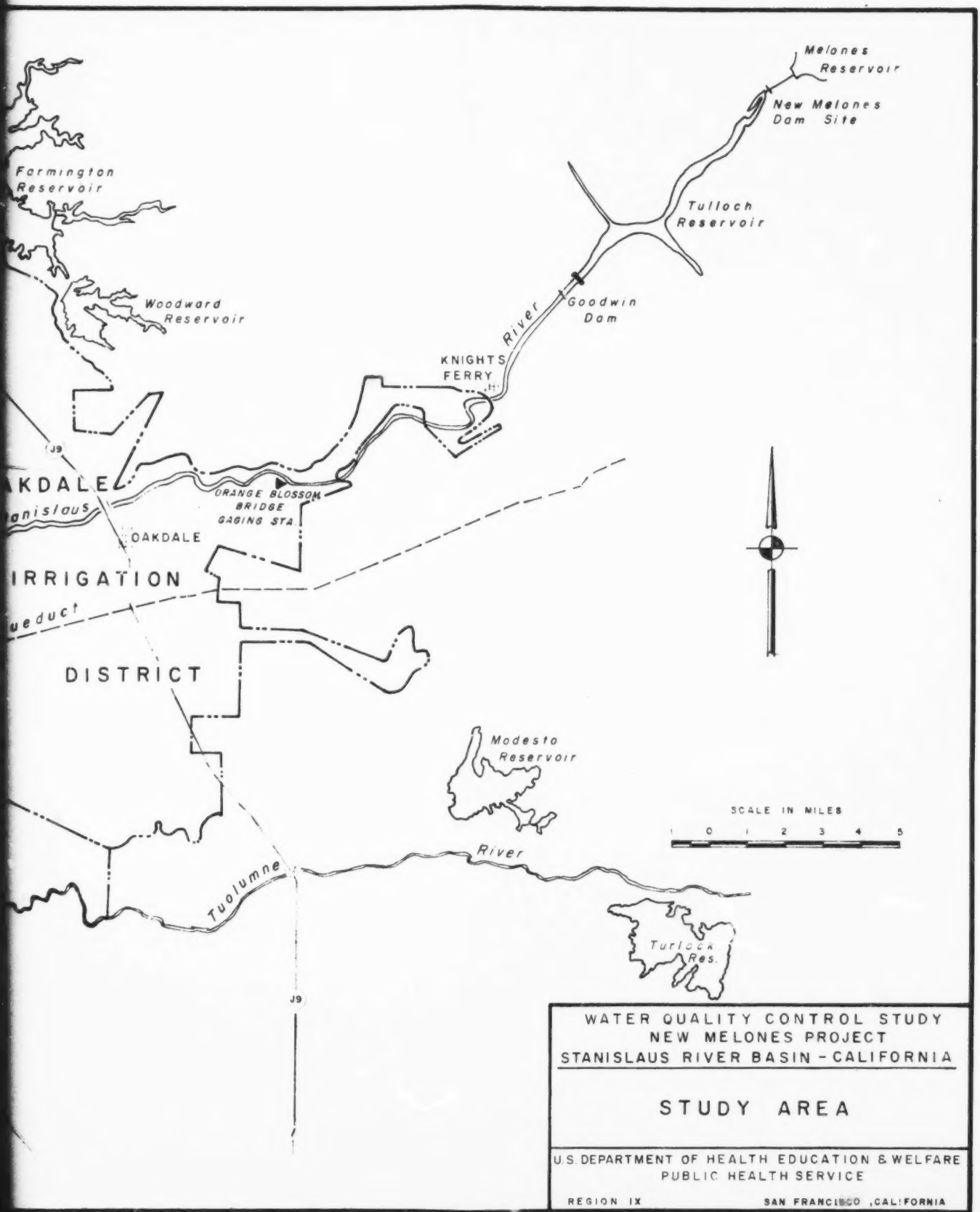
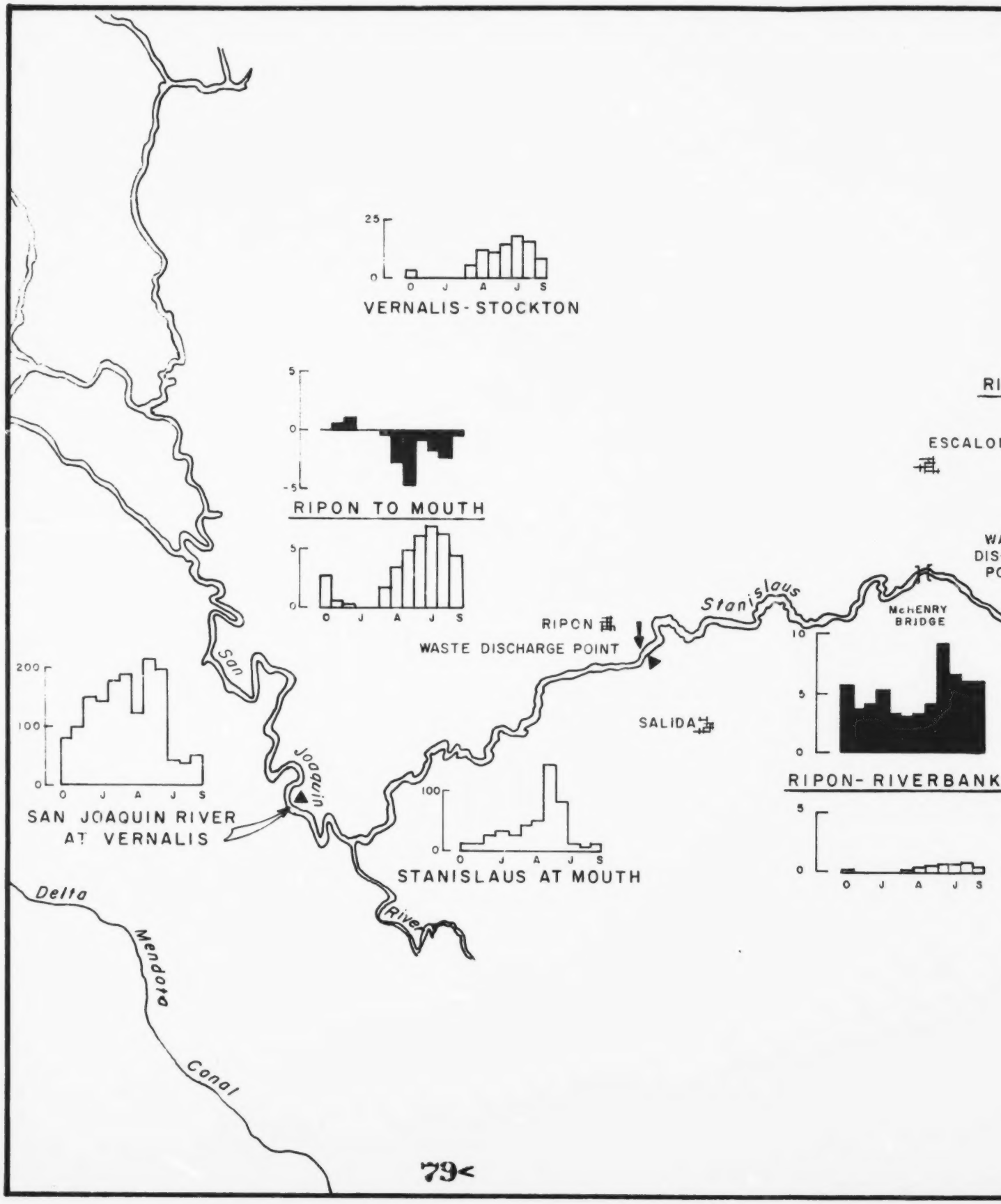
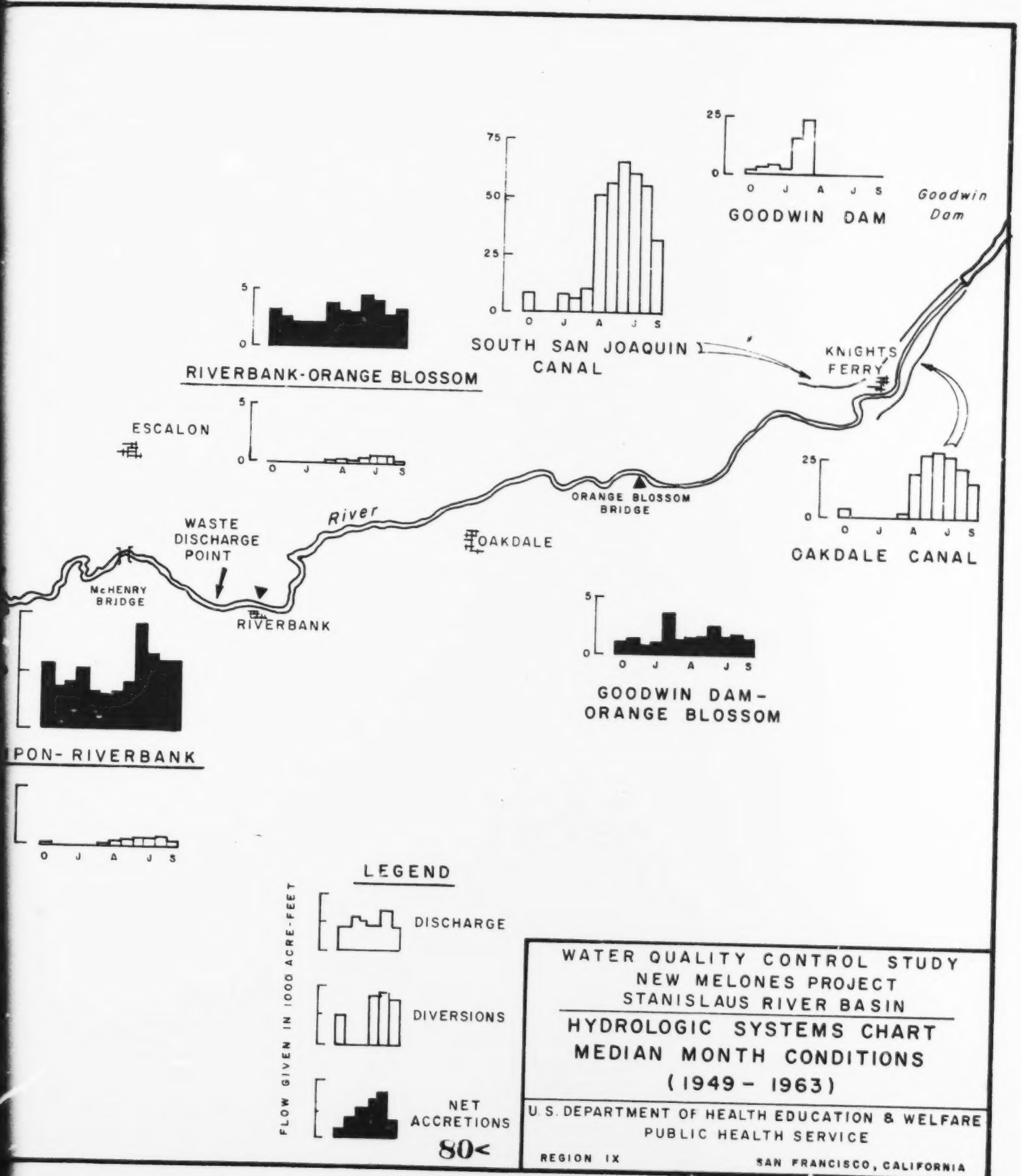

Melones Reservoir
New Melones Dam Site
Tulloch Reservoir
Goodwin Dam
River
Farmington Reservoir
Woodward Reservoir
KNIGHTS FERRY
J9
AKDALE
anislaus
ORANGE BLOSSOM BRIDGE GAGING STA
OAKDALE
IRRIGATION
ueduct
DISTRICT
Modesto Reservoir
SCALE IN MILES
1 0 1 2 3 4 5
River
Tuolumne
Turlock Res.
J9
WATER QUALITY CONTROL STUDY
NEW MELONES PROJECT
STANISLAUS RIVER BASIN - CALIFORNIA
STUDY AREA
U.S. DEPARTMENT OF HEALTH EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION IX
SAN FRANCISCO, CALIFORNIA

FIGURE 2


25
0
O J A J S
VERNALIS - STOCKTON
5
0
-5
RIPON TO MOUTH
5
0
O J A J S
RI
ESCALO
W
DIS
PO
McHENRY
BRIDGE
Stanislaus
RIPON
WASTE DISCHARGE POINT
10
5
0
RIPON - RIVERBANK
5
0
O J A J S
SALIDA
San
Joaquin
200
100
0
O J A J S
SAN JOAQUIN RIVER
AT VERNALIS
100
0
O J A J S
STANISLAUS AT MOUTH
Delta
Mendota
Canal
River

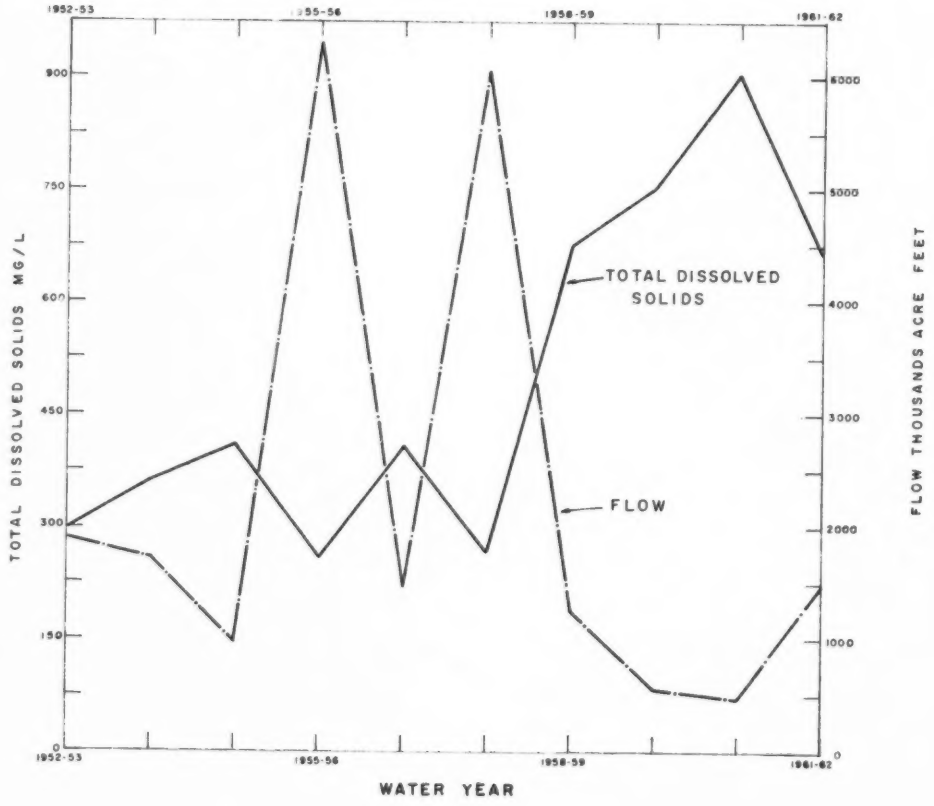


WATER QUALITY CONTROL STUDY
NEW MELONES PROJECT
STANISLAUS RIVER BASIN

HYDROLOGIC SYSTEMS CHART
MEDIAN MONTH CONDITIONS
(1949 - 1963)

U. S. DEPARTMENT OF HEALTH EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION IX SAN FRANCISCO, CALIFORNIA

FIGURE 3



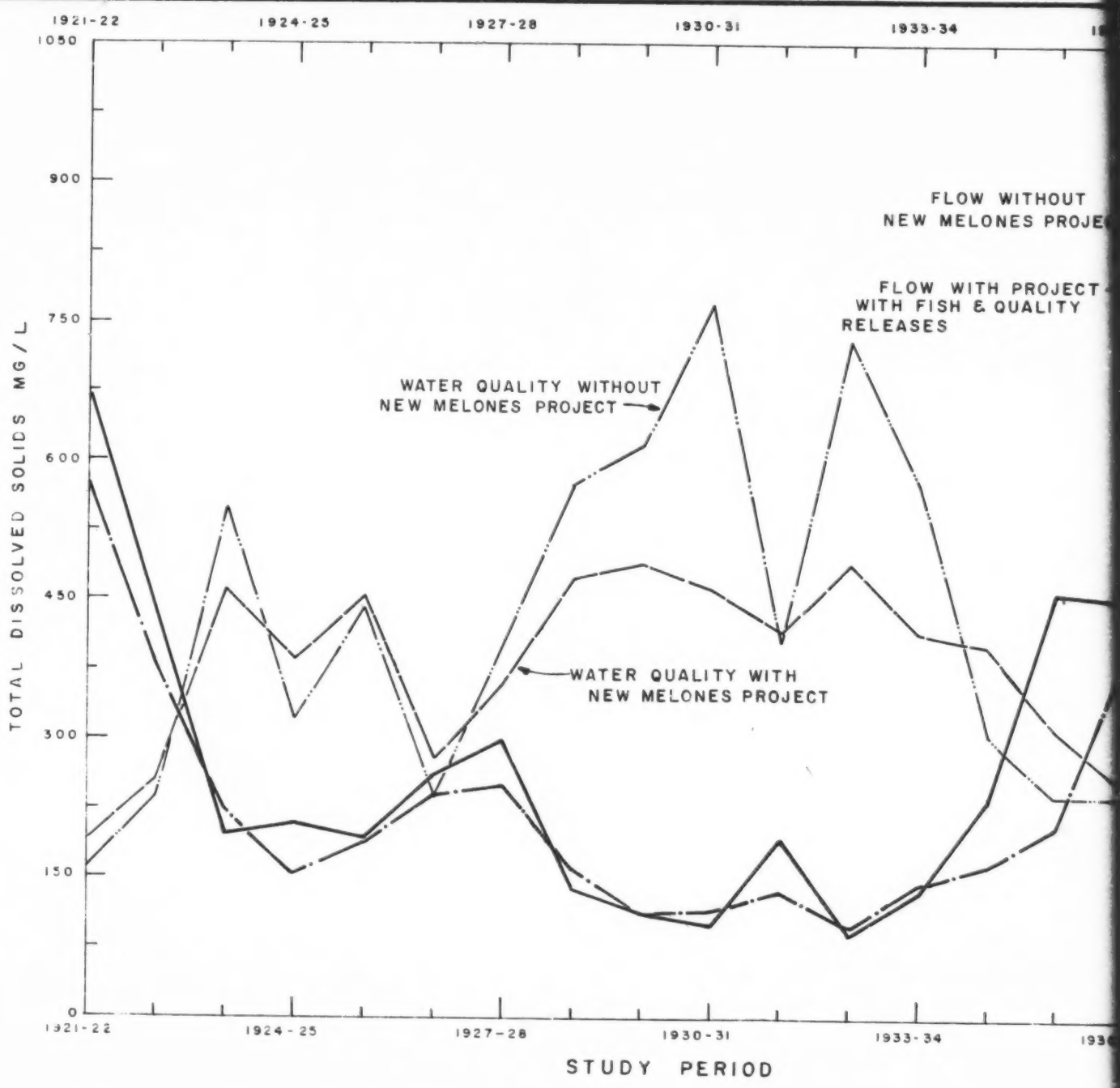
NOTE:
THIS MEAN TOTAL DISSOLVED SOLIDS CONCENTRATION IS WEIGHTED ACCORDING TO THE QUANTITY OF IRRIGATION DIVERSIONS.

WATER QUALITY CONTROL STUDY
NEW MELONES PROJECT
STANISLAUS RIVER BASIN
CALIFORNIA

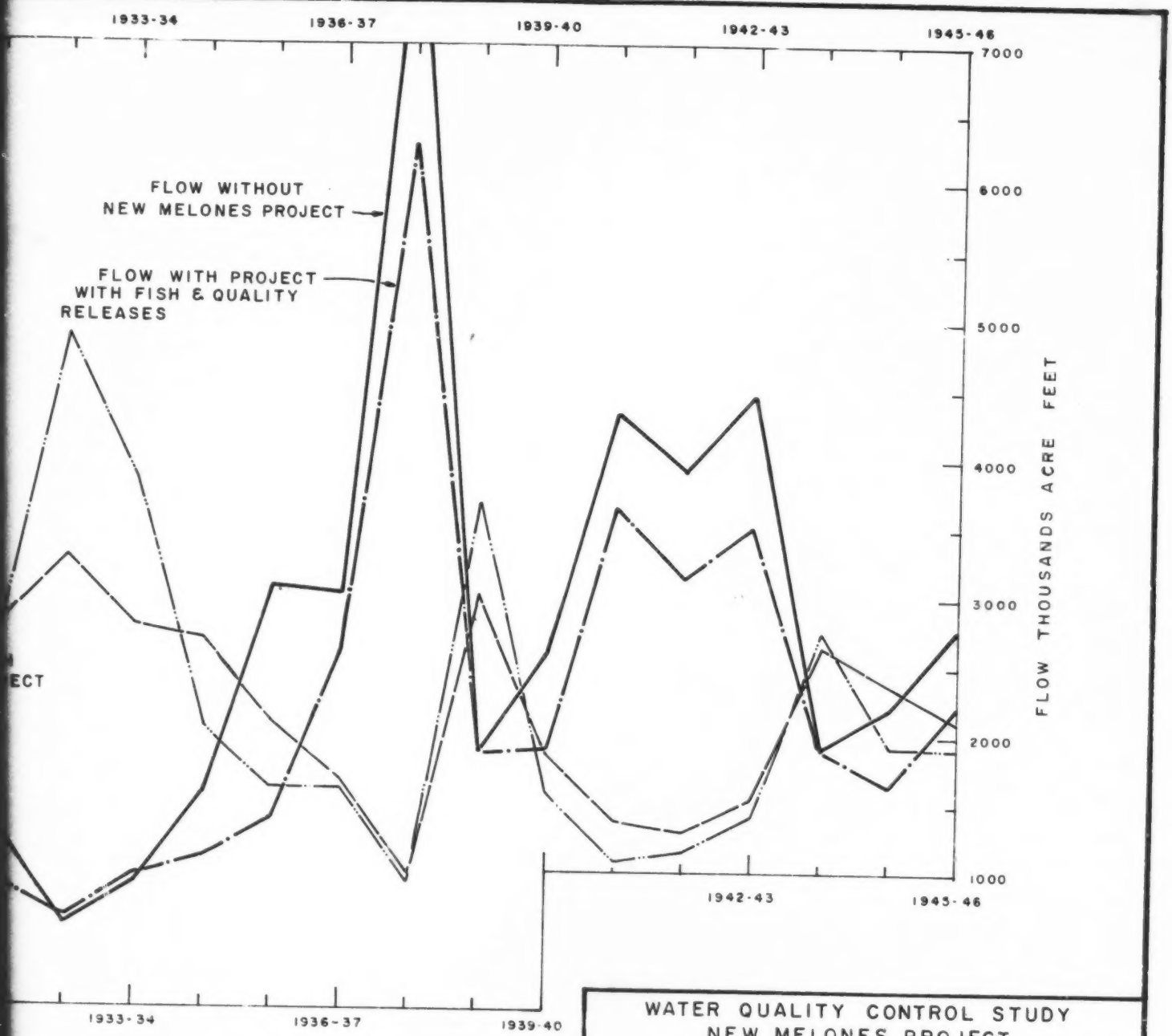
SAN JOAQUIN RIVER AT VERNALIS GAGE
ANNUAL FLOW AND MEAN TDS CONCENTRATION
1952-1962

U.S. DEPARTMENT OF HEALTH EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION IX SAN FRANCISCO, CALIFORNIA

FIGURE 4



NOTE: THIS MEAN TOTAL DISSOLVED SOLIDS CONCENTRATION IS WEIGHTED ACCORDING TO THE QUANTITY OF IRRIGATION DIVERSIONS.

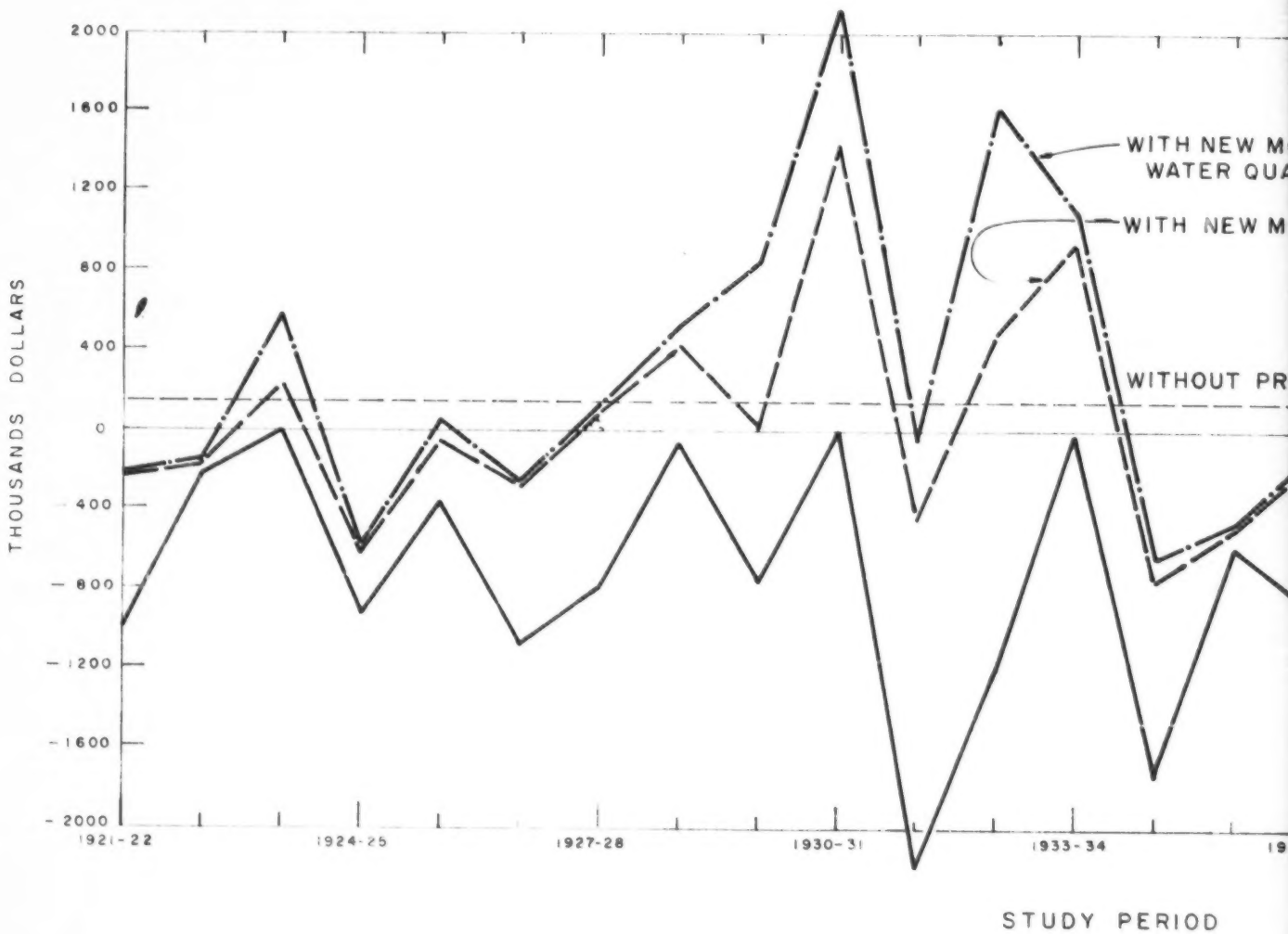


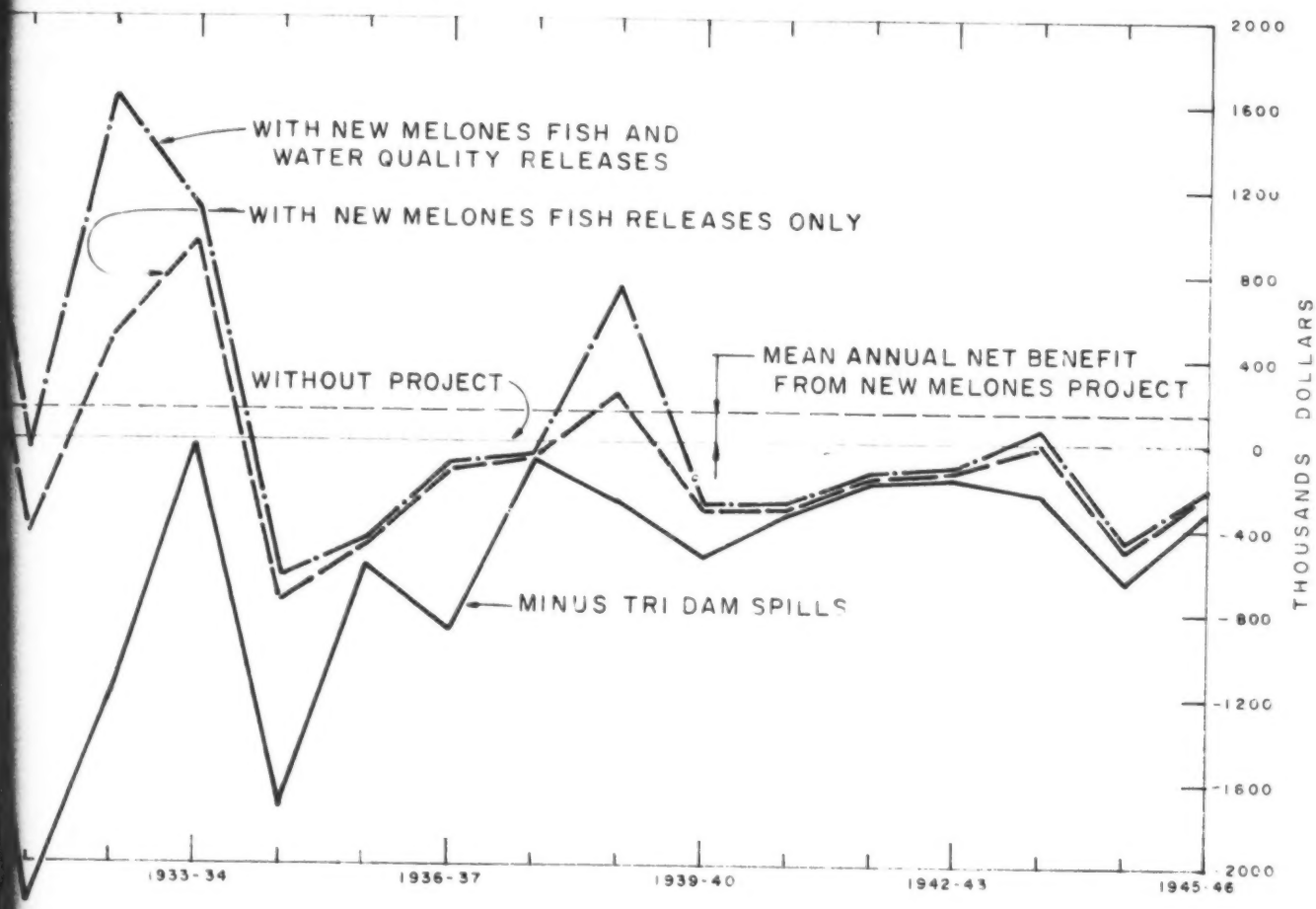
WATER QUALITY CONTROL STUDY
NEW MELONES PROJECT
STANISLAUS RIVER BASIN
CALIFORNIA

SAN JOAQUIN RIVER AT VERNALIS
ANNUAL FLOW AND MEAN TDS CONCENTRATION
FOR 2025 CONDITIONS
DURING
1921-1946 STUDY PERIOD

U.S. DEPARTMENT OF HEALTH EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION IX
SAN FRANCISCO, CALIFORNIA

FIGURE : 5


2000
1600
1200
800
400
0
400
800
1200
1600
2000
THOUSANDS DOLLARS
1921-22
1924-25
1927-28
1930-31
1933-34
WITH NEW M
WATER QUA
WITH NEW M
WITHOUT PR
STUDY PERIOD

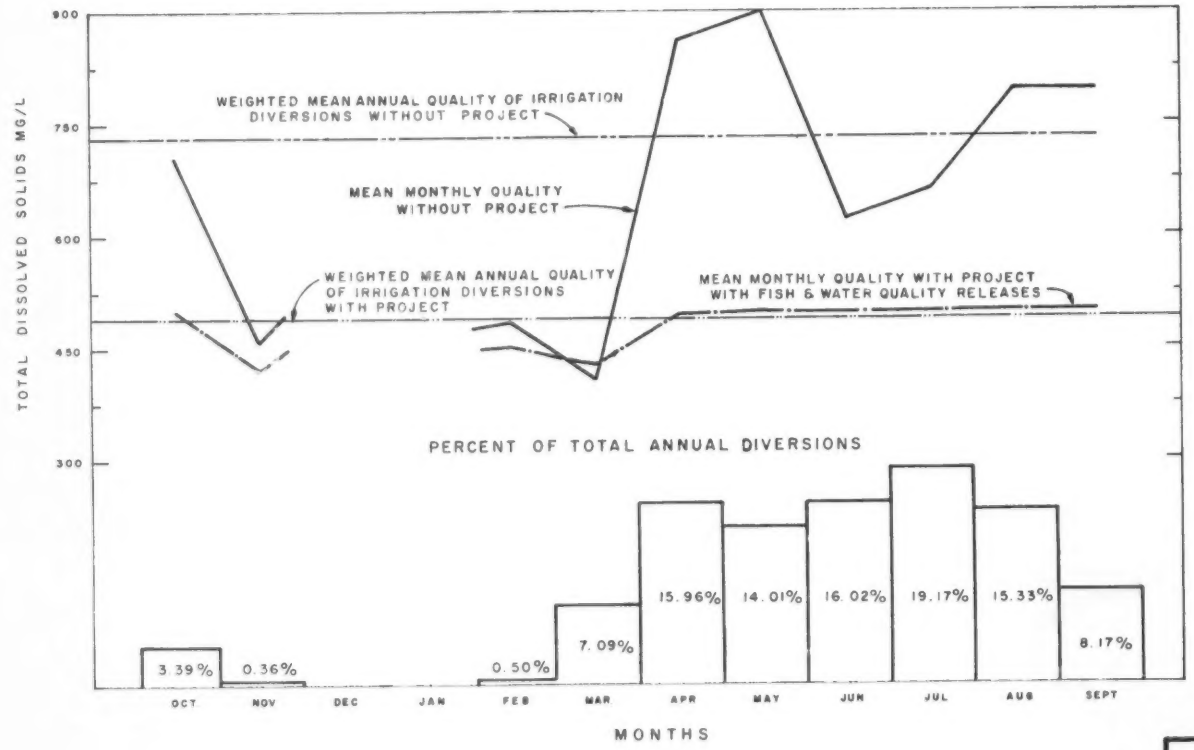


WATER QUALITY CONTROL STUDY
NEW MELONES PROJECT
STANISLAUS RIVER BASIN
CALIFORNIA

ECONOMIC IMPACT ON AGRICULTURE
FROM DIFFERENCES IN WATER QUALITY
2025 CONDITIONS

U.S. DEPARTMENT OF HEALTH EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION IX SAN FRANCISCO, CALIFORNIA

FIGURE 6



WATER QUALITY CONTROL STUDY
NEW MELONES PROJECT
STANISLAUS RIVER BASIN
CALIFORNIA

PROJECTED TDS OF IRRIGATION DIVERSIONS DURING DRY YEAR (1932-33 CONDITIONS)

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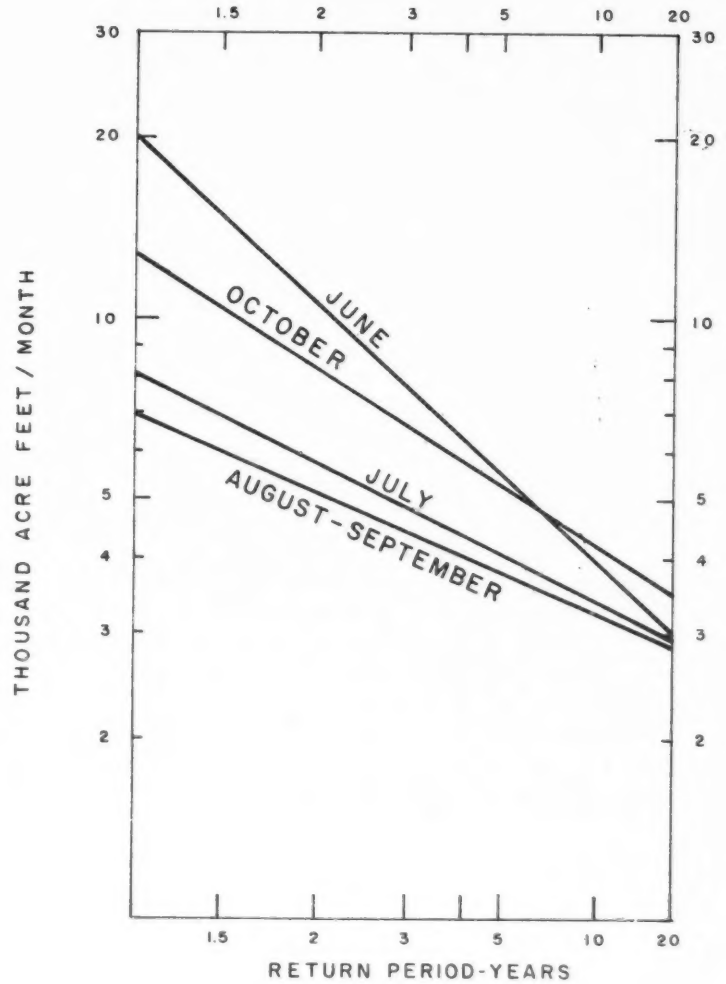
PUBLIC HEALTH SERVICE
REGION IX SAN FRANCISCO, CALIFORNIA

FIGURE 7



WATER QUALITY CONTROL STUDY
NEW MELONES PROJECT
STANISLAUS RIVER BASIN - CALIFORNIA

LOW FLOW FREQUENCY CURVES
STANISLAUS RIVER AT RIVERBANK
1949 - 1963

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PUBLIC HEALTH SERVICE
REGION IX SAN FRANCISCO, CALIFORNIA

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FIGURE 8

END